Lower Clark Fork River Subbasin

2022 Total Maximum Daily Loads

HUC 17010213

State of Idaho
Department of Environmental Quality
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Abbreviations, Acronyms, and Symbols

§303(d)	refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section
§	section (usually a section of federal or state rules or statutes)
AU	assessment unit
BAG	basin advisory group
BMP	best management practice
BURP	Beneficial Use Reconnaissance Program
C	Celsius
CFR	Code of Federal Regulations (refers to citations in the federal administrative rules)
COLD	cold water aquatic life
CGP	Construction General Permit
CWA	Clean Water Act
DEQ	Idaho Department of Environmental Quality
DWS	domestic water supply
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
F	Fahrenheit
GIS	geographic information system
HUC	hydrologic unit code
ICIS	Integrated Compliance Information System
IDAPA	refers to citations of Idaho administrative rules
IDFG	Idaho Department of Fish and Game
IDL	Idaho Department of Lands
IDWR	Idaho Department of Water Resources
IPDES	Idaho Pollution Discharge Elimination System
kWh	kilowatt-hour
LA	load allocation
LC	load capacity
MOS	margin of safety
NAIP	National Agriculture Imagery Program
NB	natural background
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
NREL	National Renewable Energy Laboratory
PCR	primary contact recreation
PNV	potential natural vegetation

SFI2	DEQ's Stream Fish Index
SHI2	DEQ's Stream Habitat Index
SMI2	DEQ's Stream Macroinvertebrate Index
SS	salmonid spawning
SWPPP	Stormwater Pollution Prevention Plan
TMDL	total maximum daily load
US	United States
USC	United States Code
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFS	United States Forest Service
USGS	United States Geological Survey
WAG	watershed advisory group
WBAG	*Water Body Assessment Guidance*
WLA	wasteload allocation

Executive Summary

The federal Clean Water Act requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the Clean Water Act, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the Clean Water Act establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards).

States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently, this list is published every 2 years as the list of Category 5 water bodies in Idaho's Integrated Report. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. This document addresses fourteen water bodies (twenty-two assessment units) in the Lower Clark Fork River subbasin that are included in Category 4a of Idaho's most recent federally approved Integrated Report (DEQ, 2020). Category 4a list water bodies that already have a TMDL.

The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered a violation of water quality standards. In these situations, natural conditions effectively become the water quality standard. For temperature impaired waters, the Idaho Department of Environmental Quality (DEQ) establishes total maximum daily load (TMDL) targets at instream conditions under the natural level of shade and channel width (or potential natural vegetation) using methodology defined in *Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar and De Varona 2009). These natural conditions are considered consistent with the water quality standards, even if they exceed numeric temperature criteria. TMDLs within this document only address perennially flowing waters. Intermittent streams as identified in the National Hydrography Dataset (NHD) at the 1:24,000 scale are not included in the analysis.

This document describes the key physical and biological characteristics of the subbasin; water quality concerns and status; pollutant sources; and recent pollution control actions in the Lower Clark Fork River subbasin, located in northern Idaho. For more detailed information about the subbasin and previous TMDLs, see the *Lower Clark Fork River Subbasin Assessment and Total Maximum Daily Loads* (DEQ, 2007).

The TMDL analysis establishes water quality targets and load capacities, estimates existing pollutant loads, and allocates responsibility for load reductions needed to return listed waters to a condition meeting water quality standards. It also identifies implementation strategies—including reasonable time frames, approach, responsible parties, and monitoring strategies—necessary to achieve load reductions and meet water quality standards.

Subbasin at a Glance

The following major streams and tributaries of the Lower Clark Fork River subbasin, located in northern Idaho (Figure A), are addressed in this TMDL:

- Johnson Creek
- Twin Creek
- Dry Creek
- Mosquito Creek
- Lightning Creek
- Morris Creek
- East Fork Creek
- Savage Creek
- Porcupine Creek
- Wellington Creek
- Rattle Creek
- Quartz Creek
- Moose Creek

These streams require temperature reductions in order to support designated and presumed beneficial uses of cold water aquatic life (COLD) and salmonid spawning (SS).

This document revises the temperature TMDLs found in the *Lower Clark Fork Subbasin Assessment and Total Maximum Daily Loads* approved by the US Environmental Protection Agency (EPA) in 2007 (DEQ 2007) (Table A). The revisions establish more accurate shade targets using updated shade-curve methodology (Shumar and De Varona 2009). TMDLs in this subbasin are being reestablished using stream shade curves specific to Idaho. The 2007 TMDL used stream shade curves from neighboring states or other regions of Idaho that hold similar vegetation communities but were not directly comparable to conditions observed in the Lower Clark Fork River subbasin. The updated stream shade curves more accurately portray conditions within the subbasin and the amount of solar input a stream receives. This TMDL does not address the sediment TMDLs in the 2007 document. Detailed information about the subbasin and previous TMDLs are provided in the 2007 TMDL document (DEQ, 2007) .

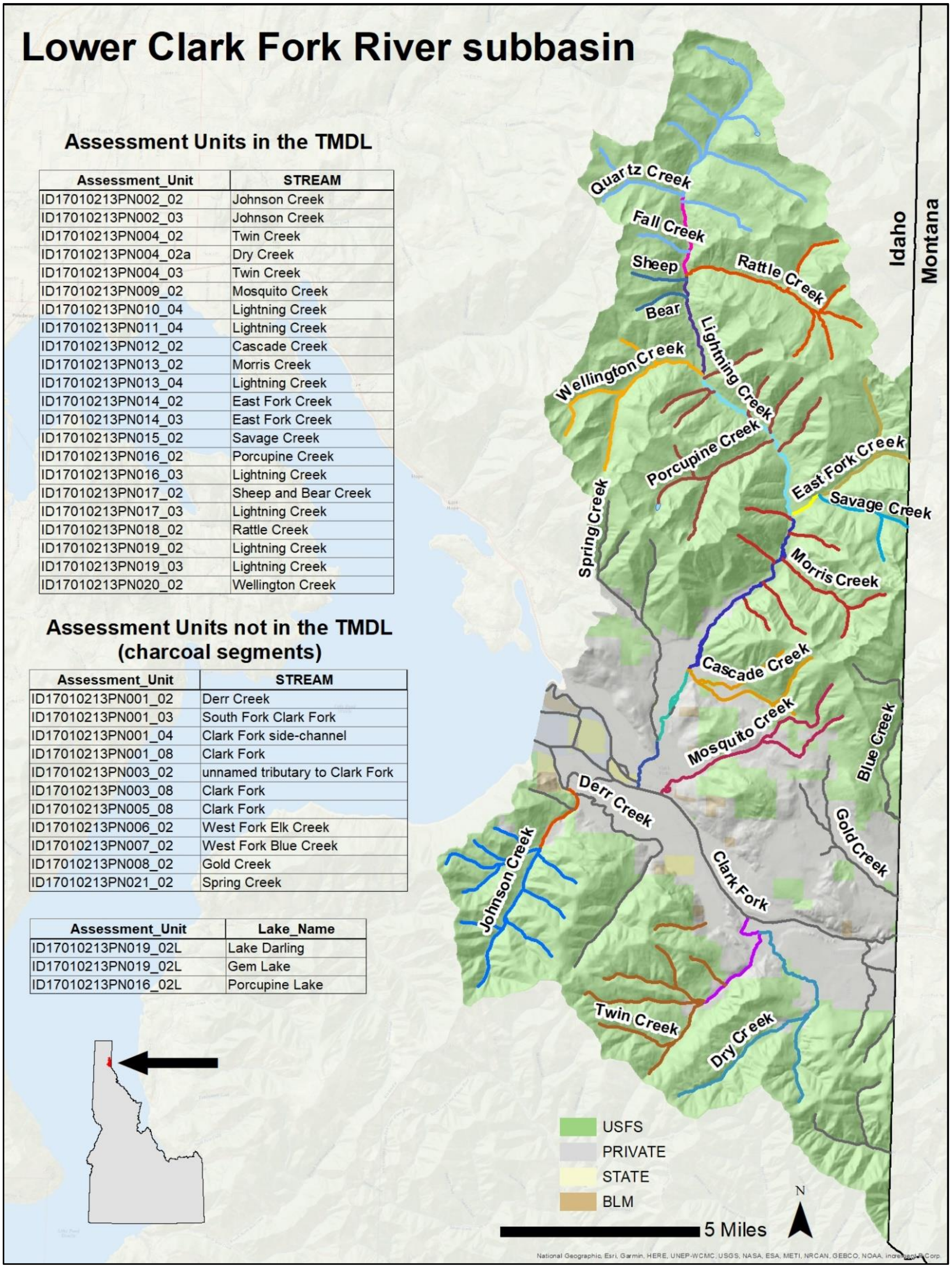

Figure A. Lower Clark Fork River subbasin.

Key Findings

The water bodies addressed in this document were identified and placed on the 1998 §303(d) list of impaired waters, or subsequent lists for reasons associated with temperature criteria violations. Biological and temperature data were originally used to determine temperature impairment of beneficial uses. DEQ developed temperature TMDLs for these waters in the 2007 *Lower Clark Fork Subbasin Assessment and Total Maximum Daily Loads (TMDL* (Table A). This 2007 TMDL included assessment unit ID17010213PN011_02, Lightning Creek – Cascade Creek to Spring Creek. This second order assessment unit was determined to not be a stream, but a side channel of the braided segment of ID17010213PN011_04, Lightning Creek – Cascade Creek to Spring Creek. The assessment unit was merge into the fourth order assessment unit, along with its allocations during the development of this TMDL. Another assessment unit change since the 2007 TMDL was the split of ID17010213PN004_02. It is now two assessment units; ID17010213PN004_02, Twin Creek – 1st & 2nd order Twin & Delyle Creek and ID17010213PN004_02a, Dry Creek. TMDLs for other pollutants and impairments in the subbasin will be addressed in a different document.

Table A. Water bodies and pollutants for which TMDLs were developed.

Water Body	Assessment Unit	Pollutant
Johnson Creek – source to mouth	ID17010213PN002_02	Temperature
Johnson Creek – source to mouth	ID17010213PN002_03	Temperature
Twin Creek – 1st & 2nd order Twin & Delyle Creek	ID17010213PN004_02	Temperature
Dry Creek	ID17010213PN004_02a	Temperature
Twin Creek – Delyle Creek to Clark Fork River	ID17010213PN004_03	Temperature
Mosquito Creek – source to mouth	ID17010213PN009_02	Temperature
Lightning Creek – Spring Creek to mouth	ID17010213PN010_04	Temperature
Lightning Creek – Cascade Creek to Spring Creek	ID17010213PN011_04	Temperature
Cascade Creek – source to mouth	ID17010213PN012_02	Temperature
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_02	Temperature
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_04	Temperature
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_02	Temperature
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_03	Temperature
Savage Creek – Idaho/Montana border to mouth	ID17010213PN015_02	Temperature
Tribs to Lightning Creek between Wellington Creek and E. Fork Creek	ID17010213PN016_02	Temperature
Lightning Creek – Wellington Creek to East Fork Creek	ID17010213PN016_03	Temperature
Lightning Creek – tribs between Wellington Creek & Rattle Creek	ID17010213PN017_02	Temperature
Lightning Creek – Rattle Creek to Wellington Creek	ID17010213PN017_03	Temperature
Rattle Creek – source to mouth	ID17010213PN018_02	Temperature
Lightning Creek – source to Rattle Creek	ID17010213PN019_02	Temperature
Lightning Creek – source to Rattle Creek	ID17010213PN019_03	Temperature
Wellington Creek – source to mouth	ID17010213PN020_02	Temperature

This TMDL is updating the 2007 TMDL using maximum shading under potential natural vegetation, which results in natural background temperature levels, to establish effective shade level targets. Shade targets were derived from system potential effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation, which was partially verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02). This process only analyzed current shade levels and did not collect any temperature data. General aquatic life use support was assessed through routine beneficial use reconnaissance program monitoring and not necessarily specific to collecting data for this TMDL. A summary of assessment outcomes is presented in Table B. Summary of assessment outcomes for §303(d)-listed assessment units.

Table B. Summary of assessment outcomes for §303(d)-listed assessment units.

Water Body	Assessment Unit	Pollutant	TMDL(s) Completed	Category in Next Integrated Report	Justification
Johnson Creek – source to mouth	ID17010213PN002_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Johnson Creek – source to mouth	ID17010213PN002_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Twin Creek – 1st & 2nd order Twin & Delyle Creek	ID17010213PN004_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Dry Creek	ID17010213PN004_02a	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Twin Creek – Delyle Creek to Clark Fork River	ID17010213PN004_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Mosquito Creek – source to mouth	ID17010213PN009_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – Spring Creek to mouth	ID17010213PN010_04	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – Cascade Creek to Spring Creek	ID17010213PN011_04	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Cascade Creek – source to mouth	ID17010213PN012_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_04	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade

Water Body	Assessment Unit	Pollutant	TMDL(s) Completed	Category in Next Integrated Report	Justification
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Savage Creek – Idaho/Montan border to mouth	ID17010213PN015_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Tribs to Lightning Creek between Wellington Creek and E. Fork Creek	ID17010213PN016_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – Wellington Creek to East Fork Creek	ID17010213PN016_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – tribs between Wellington Creek & Rattle Creek	ID17010213PN017_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – Rattle Creek to Wellington Creek	ID17010213PN017_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Rattle Creek – source to mouth	ID17010213PN018_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – source to Rattle Creek	ID17010213PN019_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – source to Rattle Creek	ID17010213PN019_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Wellington Creek – source to mouth	ID17010213PN020_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade

Four AUs in the Lower Clark Fork River subbasin are at or near potential natural vegetation and, pending additional bioassessment or other natural condition demonstrations, could be candidates for potential delisting. Section 5.4 presents average lack of shade values that indicate which AUs are at or near potential natural vegetation. All but two AUs have an average lack of shade within three shade classes of potential shade levels, under 30%. Despite average lack of shade calculations being at or close to potential shade values, there are still large solar load reductions needed in the subbasin to meet TMDL targets. Further discussed in Section 1, streams in the subbasin are highly dynamic and may be over-widened. Over-widened streams open the streambank-to-streambank tree canopy, decrease available shade, and increase solar load.

A large rain-on-snow/flood event in December 2015 and the 2018 Cougar Fire identified significant contributions to channel over-widening and channel reshaping. During the flood event, several bridges and culverts were lost throughout the subbasin. Peak flows in Lightning Creek were calculated at 7,290 cubic feet per second and washed away several restoration projects and created new flow paths in the stream. These flow calculations were the second highest recorded for Lightning Creek and only eclipsed by an extrapolated value of 16,400 cubic feet per second from an event in November 2006. The typical 25-year flood event discharge as calculated by the USGS StreamStats (*https://streamstats.usgs.gov/ss/*) is 4,700 cubic feet per second. These values and analysis were prepared by United States Forest Service (USFS) personnel after the 2015 event and shared with DEQ for this TMDL analysis.

The 2018 Cougar Fire burned along portions of Lightning Creek and within some of its small tributary drainages. While the fire scar is plainly obvious along Lightning Creek, it did not appear to create conditions that would severely impact total solar loads for entire AUs within the subbasin. The size and specific drainages affected by the 2018 Cougar Fire are discussed in Section 1 Subbasin Characterization.

It takes approximately 10–20 years for a stream system to recover from riparian disturbance, reach maturity, and provide stream stability and shade conditions that improve water quality. Given that two 500-year peak flood events and wildfire have occurred in the last 20 years, it is unsurprising that streams within the subbasin are still in a state of repair.

Public Participation

The Lower Clark Fork Watershed Advisory Group (WAG), other agencies, nongovernment organizations, and the public play a significant role in TMDL development processes. WAG participation was critical during and after the public comment period, and in implementing the TMDL.

Introduction

This document addresses 14 Category 4a water bodies, comprised of 22 assessment units (AUs), in the Lower Clark Fork River subbasin. Idaho's federally approved Integrated Report (DEQ, 2020) provides additional information on the water bodies and Category 4a designations.

This total maximum daily load (TMDL) document revises the original temperature TMDLs found in the *Lower Clark Fork Subbasin Assessment and Total Maximum Daily Loads (TMDL),* approved by the US Environmental Protection Agency (EPA) in 2007 (DEQ, 2007) (Table A) with a new approach based on an updated shade curve methodology as described in the *Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar and De Varona 2009).

The TMDL is a plan to improve water quality by limiting the thermal load to streams. Specifically, the TMDL is an estimation of the maximum thermal load that can be present in a water body and still allow that water body to meet water quality standards (40 CFR 130). The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard. For temperature-impaired waters, DEQ establishes TMDL targets at instream conditions under the natural level of shade and channel width (or potential natural vegetation [PNV]) using methodology defined in Shumar and De Varona (2009). These natural conditions are considered consistent with the water quality standards, even if it exceeds numeric temperature criteria. Effective shade targets necessary to achieve the TMDLs were established for the 22 AUs based on the concept of maximum shading under potential natural vegetation (PNV) resulting in natural background temperatures.

The first portion of this document, the subbasin assessment, presents key characteristics or updated information for water bodies identified in this TMDL, which is divided into four major sections: subbasin assessment (section 1), water quality concerns and status (section 2), pollutant source inventory (section 3), and a summary of past and present pollution control efforts (section 4). While the subbasin assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up-to-date and accurate. The subbasin assessment is used to develop a TMDL for each pollutant of concern for the Lower Clark Fork River subbasin.

Regulatory Requirements

This document was prepared in compliance with both federal and state regulatory requirements. The federal government, through the EPA, assumed the dominant role in defining and directing water pollution control programs across the country. The Idaho Department of Environmental Quality (DEQ) implements the Clean Water Act in Idaho, while EPA oversees Idaho and certifies the fulfillment of Clean Water Act requirements and responsibilities.

Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act, in 1972. The goal of this act was to “restore and maintain the chemical, physical, and biological integrity of the Nation’s waters” (33 USC §1251). The act, and the programs it has generated, has changed over the years as experience and perceptions of water quality have changed. The Clean Water Act has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to ensure “swimmable and fishable” conditions. These goals relate water quality to more than just chemistry.

The Clean Water Act requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation’s waters. States and tribes, pursuant to Section 303 of the Clean Water Act, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation’s waters whenever possible. DEQ must review those standards every 3 years, and EPA must approve Idaho’s water quality standards. Idaho adopts water quality standards to protect public health and welfare, enhance water quality, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

Section 303(d) of the Clean Water Act establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a “§303(d) list”) of impaired waters. Currently, this list is published every 2 years as the list of Category 5 waters in Idaho’s Integrated Report. For waters identified on this list, states and tribes must develop a TMDL for the pollutants, set at a level to achieve water quality standards.

DEQ monitors waters, and for those not meeting water quality standards, DEQ must establish a TMDL for each pollutant impairing the waters. However, some conditions that impair water quality do not require TMDLs. EPA considers certain unnatural conditions—such as flow alteration, human-caused lack of flow, or habitat alteration—that are not the result of discharging a specific pollutant as “pollution.” TMDLs are not required for water bodies impaired by pollution, rather than a specific pollutant. A TMDL is only required when a pollutant can be identified and, in some way, quantified.

1 Subbasin Characterization

Primarily located in the state of Montana, the 320-mile-long Clark Fork River flows from its headwaters near Butte, Montana in the Silver Bow Mountains to its mouth at Lake Pend Oreille in Idaho. This document addresses the lower-most 247 square miles of the subbasin in northern Idaho (Figure 3). The lower Clark Fork subbasin (HUC 17010213) includes the Idaho portion of the Clark Fork River that begins at the outfall of the Cabinet Gorge Dam and flows for approximately 19 miles before entering Lake Pend Oreille. The Lightning Creek watershed is the largest tributary drainage to the Clark Fork River in Idaho. Lightning Creek supports a regionally significant Bull Trout (*Salvelinus confluentus*) population and many other native fish. With approximately 75% of the subbasin in public ownership, there is a diversity of recreational opportunities as well as substantial wildlife habitat.

Lightning Creek and its major tributaries (e.g., Rattle Creek, East Fork Creek) are dynamic stream systems. Each one braids and moves channels within its valley bottom much like glacial streams (USFS, 2015a). Lower Lightning Creek is best defined as a braided channel due to its many channels, high discharge, high bedload, and historic channel shifts. Logging feasibility reports from 1913 mentioned in the United States Forest Service's (USFS) 2015 Environmental Assessment described its channel as very unstable and that flood flows frequently overtopped the banks before much of any land management had occurred in the watershed. Large floods can wash away roads, displace or destroy drainage structures (Figure 1), and deposit large amounts of woody debris and bedload into stream channels or on roadways (USFS, 2015a). Additional photos showing common conditions within the subbasin are presented in Section 2.3.3.

Figure 1. Displaced culvert in Quartz Creek.

The Lower Clark Fork River subbasin is primarily forested, but also provides agricultural use near the flood plain of the river. The town of Clark Fork surrounds Lightning Creek near the confluence with the Clark Fork River. A full description of subbasin including land use, ownership, and socioeconomic details can be found in the 2007 TMDL (DEQ, 2007).

The geologic history, topography, elevation, climate, and wildfire regime of the Lightning Creek watershed have a major impact on the riparian vegetation and stream width variables analyzed in relation to achieving potential natural vegetation (Craig Nelson, DEQ 2020). The Lightning Creek drainage is naturally prone to mass failures due to the amount of loose glacial drift deposited throughout the area. The watershed’s steep slopes, incised drainages, and loose glacial drift contribute to the naturally occurring failures. The combination of the local topography and geology create highly sensitive land types susceptible to failure due to high-intensity rains or rain-on-snow events. Another compounding factor for mass failures is the amount of exposed bedrock (Figure 2). The runoff from rains concentrates quickly in areas of exposed bedrock and amplifies the potential for failure (USFS, 2015a). A more detailed discussion of the local geology, soils, and weather patterns specific to the Lightning Creek drainage can be found in the USFS’s 2015 Environmental Assessment Treasured Landscapes Recreation Project document (USFS, 2015a).

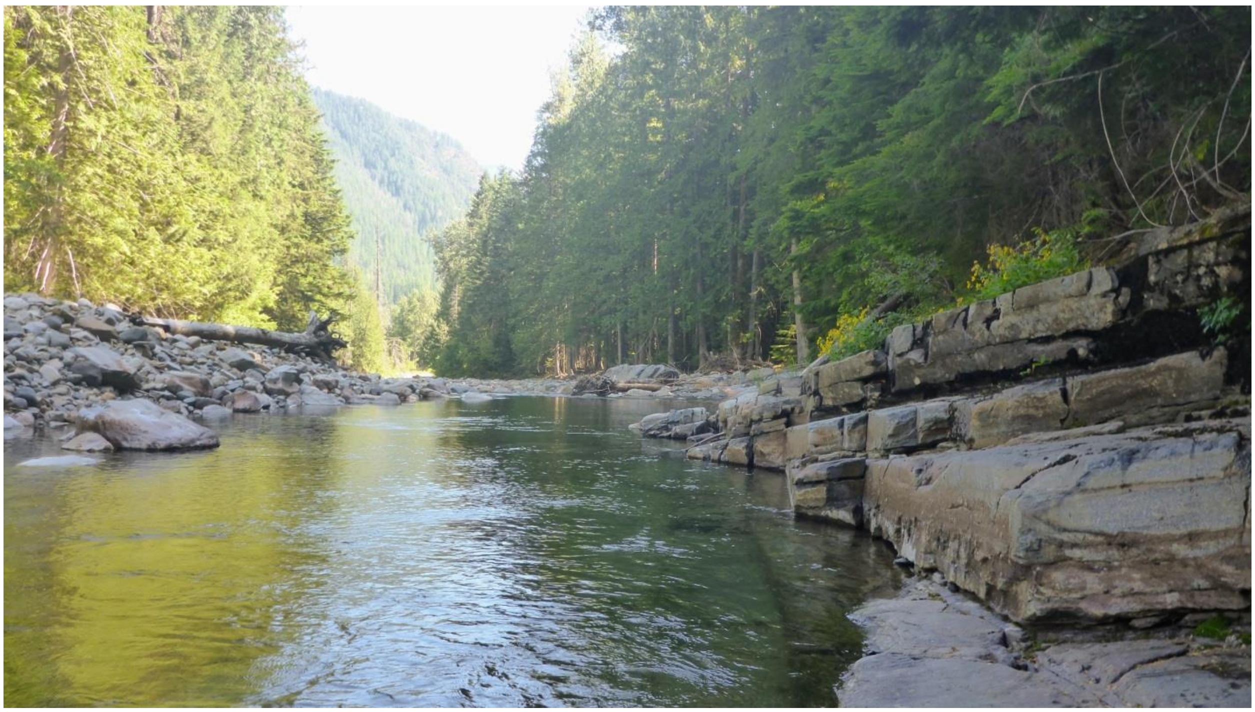

Figure 2. Example of exposed bedrock in Lightning Creek.

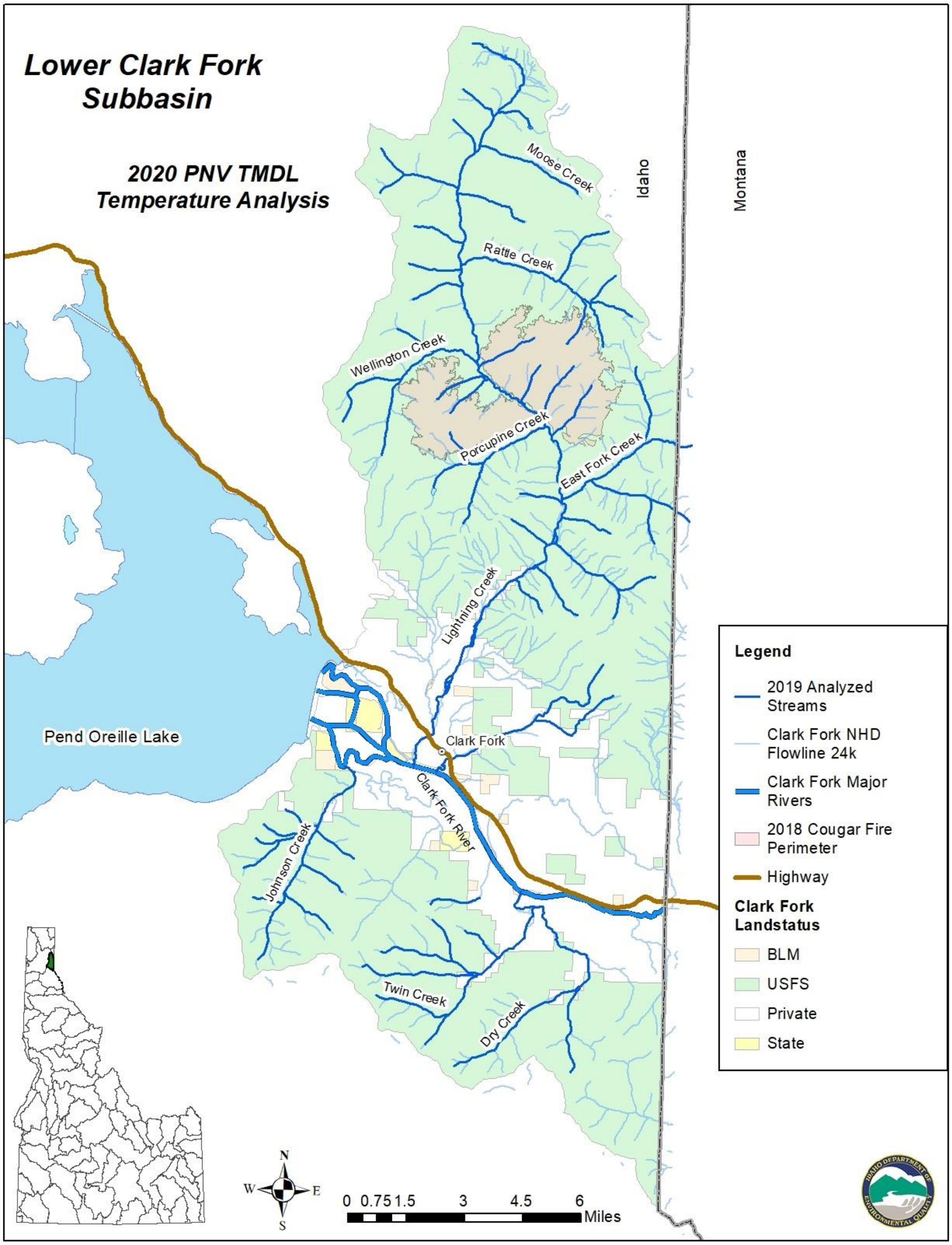

Figure 3. Lower Clark Fork River subbasin.

The 2018 Cougar Fire burned through approximately 7,800 acres from July to November 2018. The fire burned in smaller tributary watersheds to Lightning Creek (e.g., Steep, Jost, Mud Creeks). Small sections of the Wellington Creek and Porcupine Creeks watersheds to the west of Lightning Creek were also impacted. Portions of the East Fork Creek drainage and the highest parts of the Rattle Creek watershed were also affected by the 2018 Cougar Fire (Figure 3). Despite the size and location of the fire, it did not appear to create exceedingly problematic issues for the watershed.

Through the course of writing this TMDL additional data about the fire severity of the 2018 Cougar Fire has been released. The Monitoring Trends in Burn Sensitivity (MTBS) interactive fire mapping program data (*https://www.mtbs.gov/viewer/index.html*) indicates that approximately 5,300 acres within the Cougar Fire perimeter burned at moderate to high fire severities. Fire severity is the degree to which a site has been altered by fire's intensity and residence time (NWGC, 2005). According to the MTBS program, burn severity is a combination of direct and indirect effects that occur within one growing season of a fire. Moreover, burn severity primarily relates to visible changes in biomass and their data focuses on the effects of fire on an area's vegetation (Eidenshink et al, 2007). A few key characteristics of a high-severity fire include ground cover that is nearly entirely consumed; woody debris deeply charred with ash with charcoal remaining. Overstory trees generally exhibit nearly 75% mortality and char heights from ground flames often exceeds four meters. New tree establishment can occur within 1–3 years, but this fire severity can generally be understood to be stand reducing and forest redevelopment may take many decades (MTBS, 2020a).

2 Water Quality Concerns and Status

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

Section 303(d) of the Clean Water Act states that waters that are unable to support their beneficial uses and do not meet water quality standards must be listed as water quality limited. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

2.1.1 Assessment Units

Assessment units (AUs) are groups of similar streams that have similar land use practices, ownership, or land management. However, in Idaho stream order is the main basis for determining AUs—even if ownership and land use change significantly, the AU usually remains the same for the same stream order.

Using AUs to describe water bodies offers many benefits; primarily that all waters of the state are defined consistently. AUs are a subset of water body identification numbers, which allows them to relate directly to the water quality standards.

2.1.2 Listed Waters

Table 1 presents each AU in the subbasin analyzed as part of this TMDL document (i.e., AUs in Category 4a of the Integrated Report). AUs in Category 4a are those that have had a TMDL previously completed and approved by the EPA. The most recently approved TMDL for the Lower Clark Fork subbasin was in 2007.

Table 1. Lower Clark Fork River subbasin Category 4a temperature impaired assessment units

Water Body	Assessment Unit	Pollutant
Johnson Creek – source to mouth	ID17010213PN002_02	Temperature
Johnson Creek – source to mouth	ID17010213PN002_03	Temperature
Twin Creek – 1st & 2nd order Twin & Delyle Creek	ID17010213PN004_02	Temperature
Dry Creek	ID17010213PN004_02a	Temperature
Twin Creek – Delyle Creek to Clark Fork River	ID17010213PN004_03	Temperature
Mosquito Creek – source to mouth	ID17010213PN009_02	Temperature
Lightning Creek – Spring Creek to mouth	ID17010213PN010_04	Temperature
Lightning Creek – Cascade Creek to Spring Creek	ID17010213PN011_04	Temperature
Cascade Creek – source to mouth	ID17010213PN012_02	Temperature
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_02	Temperature
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_04	Temperature
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_02	Temperature
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_03	Temperature
Savage Creek – Idaho/Montana border to mouth	ID17010213PN015_02	Temperature

Tribs to Lightning Creek between Wellington Creek and E. Fork Creek	ID17010213PN016_02	Temperature
Lightning Creek – Wellington Creek to East Fork Creek	ID17010213PN016_03	Temperature
Lightning Creek – tribs between Wellington Creek & Rattle Creek	ID17010213PN017_02	Temperature
Lightning Creek – Rattle Creek to Wellington Creek	ID17010213PN017_03	Temperature
Rattle Creek – source to mouth	ID17010213PN018_02	Temperature
Lightning Creek – source to Rattle Creek	ID17010213PN019_02	Temperature
Lightning Creek – source to Rattle Creek	ID17010213PN019_03	Temperature
Wellington Creek – source to mouth	ID17010213PN020_02	Temperature

2.2 Applicable Water Quality Standards and Beneficial Uses

Idaho water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as described briefly in Appendix A. The *Water Body Assessment Guidance* (DEQ, 2016) provides a more detailed description of beneficial use identification for use assessment purposes.

Beneficial uses include the following:

- Aquatic life support—cold water, seasonal cold water, warm water, salmonid spawning (SS), and modified subcategories
- Contact recreation—primary (e.g., swimming) or secondary (e.g., boating)
- Water supply—domestic, agricultural, and industrial
- Wildlife habitats
- Aesthetics

2.2.1 Beneficial Uses in the Subbasin

Temperature is a water quality value directly linked to the life cycle of fish and other aquatic species. Natural factors that influence stream temperature include elevation, channel orientation, climate, riparian vegetation, and channel shape. Human factors that influence stream temperature include point source discharges, riparian zone alteration, channel alteration, and flow alteration.
Elevated stream temperatures can be harmful to fish at all life stages, especially in combination with other habitat limitations (e.g., food availability, low dissolved oxygen). Acceptable temperature ranges vary for different fish species, but the coldwater fish are the least tolerant of high water temperatures. Juvenile fish are even more sensitive to the negative impacts of increased stream temperatures. Common consequences for fish exposed to short or long-term excess temperatures include decreased vitality and survivability.

Table 2 presents the designated or presumed beneficial uses of streams in Category 4a that were analyzed as part of this TMDL process.

Table 2. Lower Clark Fork River subbasin temperature-impaired Category 4a stream beneficial uses

Water Body	Assessment Unit	COLD	SS	PCR	SCR	DWS	IWS	AWS	A	W
Johnson Creek – source to mouth	ID17010213PN002_02	X	X	—	X	—	X	X	X	X
Johnson Creek – source to mouth	ID17010213PN002_03	X	X	—	X	—	X	X	X	X
Twin Creek – 1st & 2nd order Twin & Delyle Creek	ID17010213PN004_02	X	X	—	X	—	X	X	X	X
Dry Creek	ID17010213PN004_02a	X	X	—	X	—	X	X	X	X
Twin Creek – Delyle Creek to Clark Fork River	ID17010213PN004_03	X	X	X		—	X	X	X	X
Mosquito Creek – source to mouth	ID17010213PN009_02	X	X	—	X	—	X	X	X	X
Lightning Creek – Spring Creek to mouth	ID17010213PN010_04	X	X	X	—	X	X	X	X	X
Lightning Creek – Cascade Creek to Spring Creek	ID17010213PN011_04	X	X	X	—	X	X	X	X	X
Cascade Creek – source to mouth	ID17010213PN012_02	X	X	—	X	—	X	X	X	X
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_02	X	X	X	—	X	X	X	X	X
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_04	X	X	X	—	X	X	X	X	X
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_02	X	X	—	X	—	X	X	X	X
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_03	X	X	X	—	—	X	X	X	X
Savage Creek – Idaho/Montana border to mouth	ID17010213PN015_02	X	X	—	X	—	X	X	X	X
Tribs to Lightning Creek between Wellington Creek and E. Fork Creek	ID17010213PN016_02	X	X	X	—	X	X	X	X	X
Lightning Creek – Wellington Creek to East Fork Creek	ID17010213PN016_03	X	X	X	—	X	X	X	X	X
Lightning Creek – tribs between Wellington Creek & Rattle Creek	ID17010213PN017_02	X	X	X	—	X	X	X	X	X
Lightning Creek – Rattle Creek to Wellington Creek	ID17010213PN017_03	X	X	X	—	X	X	X	X	X
Rattle Creek – source to mouth	ID17010213PN018_02	X	X	—	X	—	X	X	X	X
Lightning Creek – source to Rattle Creek	ID17010213PN019_02	X	X	X	—	X	X	X	X	X
Lightning Creek – source to Rattle Creek	ID17010213PN019_03	X	X	X	—	X	X	X	X	X
Wellington Creek – source to mouth	ID17010213PN020_02	X	X	—	—	—	X	X	X	X

Beneficial uses: Cold Water Aquatic Life (COLD), Salmonid Spawning (SS), Primary Contact Recreation (PCR), Secondary Contact Recreation (SCR), Domestic Water Supply (DWS), Industrial Water Supply (IWS), Agricultural Water Supply (AWS), Aesthetic (A), Wildlife Habitat (W)

2.2.2 Water Quality Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of water quality criteria, which include *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity (Appendix B) and *narrative* criteria for pollutants such as sediment and nutrients (IDAPA 58.01.02.250–251). For more about temperature criteria and natural background provisions relevant to the PNV approach, see Appendix B.

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.050.02. The procedure relies heavily upon biological parameters and is presented in detail in the *Water Body Assessment Guidance* (DEQ, 2016). This guidance requires DEQ to use the most complete data available to make beneficial use support status determinations.

Native salmonid species inhabiting the lower Clark Fork River subbasin are Bull Trout, Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*), and Kamloops Rainbow Trout (*Oncorhynchus mykiss kamloops*). In 1999, Bull Trout was listed as a threatened species by the US Fish and Wildlife Service (USFWS 1999). The State of Idaho Bull Trout Conservation Plan (Batt, 1996) and the Idaho Department of Fish and Game 2019–2024 Fisheries Management Plan (IDFG, 2019) include large portions of the Lower Clark Fork River subbasin as waters producing Bull Trout. The US Fish and Wildlife Service identified the Clark Fork River, and large stretches of Lightning Creek and some tributaries, as critical Bull Trout habitat under the 2010 final Bull Trout Critical Habitat Rule (USFWS, 2010). The State of Idaho developed water temperature criteria to protect the species, (IDAPA 58.01.02.250.02.g). EPA also promulgated Bull Trout water quality temperature criteria (40 CFR 131.33).

Fisheries data collected in support of DEQ's beneficial use reconnaissance program (BURP) and data collected by the Idaho Department of Fish and Game (IDFG) and AVISTA (Frawley et.al 2019) indicate SS is an existing use throughout the subbasin. TMDLs created for the subbasin will also be protective of the existing SS use throughout the subbasin. Based on the species present, SS time periods and the associated water quality standard will be applied to all streams within the subbasin. Based on the elevation of the subbasin and the species present, the spring spawning time period would encompass May 1 – July 31 and the fall spawning time period would encompass August 15 – November 15. Bull Trout spawning occurs in September and October. Appendix B details the temperature standards, including Bull Trout temperature standards, and SS time periods to be applied to streams in the Lower Clark Fork River subbasin.

2.3 Summary and Analysis of Existing Water Quality Data

Even though this TMDL is solely focused on temperature impairments, data collection activities in streams that do not directly relate to temperature may be relevant in describing overall stream conditions. DEQ's BURP data, as well as data from other agencies (e.g., IDFG, USFS), are included in this section.

2.3.1 DEQ Beneficial Use Reconnaissance Program

Table 3 provides the BURP data related to the COLD beneficial use support collected since 2015.

Table 3. BURP (2015 – 2019) data for the Lower Clark Fork River subbasin.

Stream Name	Assessment Unit	BURP Location ID	SMI2	SFI2	SHI2	Index Score Average
East Fork Creek	ID17010213PN014_03	2015SDEQA162	2	—	1	1.50
East Fork Creek	ID17010213PN014_02	2016SCDAA030	2	1	2	1.67
Morris Creek	ID17010213PN013_02	2016SCDAA032	3	2	3	2.67
Lightning Creek	ID17010213PN019_02	2016SCDAA033	3	1	2	2.00
Deer Creek	ID17010213PN019_02	2017SDEQA0183	2	—	3	2.50
UNT to Clark Fork River	ID17010213PN003_02	2019SCDAA003	*Stream dry*			
UNT to Clark Fork River	ID17010213PN003_02	2019SCDAA004	*Stream dry*			

NA = not assessed; SMI2 = stream macroinvertebrate index; SFI2 = stream fish index; SHI2 = stream habitat index

Index score averages of greater than 2.00 indicate that an AU, as represented by a BURP sample location, may fully support aquatic life. However, this data may not be robust enough to make any strong assertions about all the AUs. It will be up to the individual DEQ assessor to determine whether a delisting of these AUs is appropriate. A full description of index scores and how they are calculated can be found in DEQ's water body assessment guidance (DEQ, 2016).

2.3.2 Idaho Department of Fish and Game Salmonid Monitoring

Research and monitoring by IDFG has occurred on a 5-year rotational basis on 25 tributaries to Lake Pend Oreille. Monitoring is largely focused on abundance and distribution of salmonids through electrofishing surveys and Bull Trout redd counts. Both efforts were funded by the Idaho Tributary Habitat Acquisition and Fishery Enhancement Program of the Clark Fork Settlement Agreement that supports ongoing research and monitoring in Idaho tributaries. Methods and results of electrofishing surveys can be found in Frawley et.al 2019. Methods and results of redd count surveys can be found in Jakubowski and Bouwens 2019.

Results of the IDFG monitoring indicate Bull Trout exist in all watersheds relevant to this TMDL except Mosquito Creek (Table 4). However, Bull Trout abundance has decreased between monitoring years in many of the watersheds. Bull Trout density was highest in Savage, Rattle, and Johnson Creeks (Table 5). Most Bull Trout spawning was observed in East Fork, Rattle, and Johnson Creeks. Rainbow Trout and Westslope Cutthroat Trout were observed in all watersheds relevant to this TMDL, except for the absence of Rainbow Trout in Johnson Creek.

Table 4. Mean density estimates (fish/100m^2) as reported in Frawley et.al (2019)[1]

Stream	Year	BLT	BRK	BRN	RBT	WCT	BBHY	WRHY	Total
Mosquito	2018	0.0	3.6	0.1	0.3	7.4	0.0	0.5	11.9
ID17010213PN009_02	2013	0.0	4.9	0.2	0.0	3.4	0.0	0.2	8.7
East Fork Creek	2017	0.3	0.1	0.0	10.5	2.7	0.0	1.7	15.3
ID17010213PN014_02	2012	3.1	0.1	0.0	2.8	4.5	0.5	0.4	11.4
Porcupine Creek	2017	0.3	3.4	0.0	0.3	12.1	0.0	0.3	16.4
ID17010213PN016_02	2012	1.0	5.4	0.0	0.0	10.5	0.0	0.9	17.8
Rattle Creek	2017	0.8	0.0	0.0	0.3	5.1	0.0	0.1	6.3
ID17010213PN018_02	2012	4.6	0.0	0.0	0.6	5.8	0.0	0.1	11.1
Savage Creek	2017	1.6	0.0	0.0	0.2	9.3	0.0	1.7	12.8
ID17010213PN015_02	2012	5.1	0.0	0.0	<0.1	3.9	0.0	0.7	9.7
Johnson Creek	2014	1.0	0.0	0.0	0.0	7.0	0.0	0.0	8.0
ID17010213PN002_03	2009	1.4	0.0	0.0	0.0	5.1	0.0	0.0	6.5
Twin Creek	2014	0.1	7.6	0.5	1.3	3.3	0.0	1.4	14.2
ID17010213PN004_03	2009	0.0	2.7	0.3	2.0	3.8	0.0	0.0	8.8

[1]BLT = Bull Trout, BRK = Brook Trout, BRN = Brown Trout, RBT = Rainbow Trout, WCT = Westslope Cutthroat Trout, BBHY = Brook Trout x Bull Trout hybrid, WRHY = Westslope Cutthroat x Rainbow Trout Hybrid.

Table 5. Average Bull Trout redd counts as reported in Jakubowski and Bouwens (2019).

Stream	1998–2017	2008–2017
Lightning Creek	8	7
East Fork Creek	45	39
Savage Creek	7	6
Porcupine Creek	7	9
Rattle Creek	31	35
Johnson Creek	30	34
Twin Creek	6	1

2.3.3 United States Forest Service Stream Surveys

Stream surveys conducted by the Idaho Panhandle National Forest primarily focus on stream stability and sediment mobility. Even though this TMDL presents prescribed daily loads related to temperature impairments, stream stability is closely associated with water temperature. The factors that control water temperature (e.g., channel width, vegetative canopy cover) are also correlated with stream stability. High amounts of streambank erosion destabilize the soils and lead to the loss of streamside vegetation at high flows, which widens a stream and creates breaks in canopy cover. Stream channel widening, and subsequent impacts to width-to-depth ratios, affects the insulating capacity of streams by moving streamside vegetation away from the water's edge, reducing shade on the water's surface, and creating more surface area for solar loading(Shumar & De Varona, 2009).

East Fork Creek (ID17010213PN014_02, ID17010213PN017_03)

East Fork Creek was surveyed by the USFS in July 2017 after discussions with DEQ (USFS 2017a and USFS 2017b). The survey was a walk-through survey from the mouth at Lightning Creek upstream to the confluence with Char Creek. Results of the survey indicate much of the AU is lacking in thermal protection for salmonids, especially Bull Trout.

Only 30% of the surveyed reach was boulder/bedrock habitat (Figure 2). This habitat had deeper water, a higher percentage of canopy cover, and more in-stream cover for thermal refugia. The remaining 70% was multi-threaded cobble habitat (Figure 3, Figure 4). The multiple channels were only inches deep and ranged from 3–8 feet in width with little to no vegetation, resulting in intense thermal input. The lack of cover resulted in higher stream temperatures than the boulder/bedrock habitat. Overall, the stream lacked large, woody debris and had moderate to high mobilization of bank and point bar material due to a lack of riparian vegetation (USFS 2017a). Most large wood in the channel was from mass failure of hillsides above the channel and recruitment from eroding banks. However, recruited wood typically lacks stability, as evidenced by the abundance of unvegetated bedload deposits (USFS 2017b).

Bull Trout were observed at the confluence of Savage Creek where colder water from Savage Creek entered and created a boulder plunge pool, with fry observed in side channels (USFS 2017a).

Observations of road infrastructure remediation work completed between 2009–2011 (Section 4.1) showed drainage structure removals were functioning as designed, but legacy effects of the failing road system would continue to disrupt channel equilibrium for some time (USFS 2017a). Some large wood structures installed in 2010 had washed away in the December 2015 high-magnitude rain-on-snow event and some large wood structures were still in place collecting additional wood (USFS 2017b).

Figure 4. Plunge pools and pools along bedrock-dominated stream channel.
(Photo courtesy of USFS, Sandpoint Ranger Station)

Figure 5. East Fork Creek cobble-dominated stream with a relative lack of riparian vegetation.
(Photo courtesy of USFS, Sandpoint Ranger Station)

Figure 6. Wide, shallow, exposed channel in East Fork Creek.
(Photo courtesy of USFS, Sandpoint Ranger Station)

Wellington Creek (ID17010213PN020_02)

Wellington Creek was surveyed by the USFS in July 2017 after discussions with DEQ over the relevance of the 303(d) listing for sediment (USFS 2017b). The survey consisted of two walk-through surveys:

- From the mouth at Lightning Creek upstream to Wellington Falls
- Wellington Creek and North Fork Wellington Creek above the falls.

Lower Wellington Creek is characterized by a large depositional zone at the mouth that created a wide floodplain. The depositional zone with aggradation was most likely caused by sediment sources upstream combining with backwater conditions during high flow conditions in Lightning Creek. Large wood and log jams were observed on the floodplain. Bull trout were observed further upstream in a bedrock canyon with pools and boulder/bedrock plunges. The pools, along with a good riparian and forest canopy, contributed to the low water temperatures observed in this reach (USFS 2017b).

Upper Wellington Creek, above the falls, is characterized by a high-energy transport reach with large boulder/cobble with few large woody debris. Bedrock and boulders provided good pool habitat with thermal protection (Figure 5). The mature forest at the stream channel provided good canopy cover and bank stabilization. The decommissioned road network had no issues. The survey concluded the hydrologic conditions within the channel and flood prone area are within natural stream conditions (USFS 2017b).

Figure 7. Wellington Creek entering the canyon above the falls.
Photo courtesy of USFS, Sandpoint Ranger Station.

Lightning Creek from Rattle Creek to East Fork Creek (ID17010213PN016_03 – ID17010213PN017_03)

In August 2017, the USFS performed a hydrologic and fish habitat assessment of 6.5 miles of the main channel of middle Lightning Creek from the confluence with East Fork Creek to the confluence with Rattle Creek. Survey results determined that the mature forest was largely intact for the entire length of the survey—broken only by large riparian wetlands, encroaching USFS roads, and past washouts of old road segments. The mature forest provides some thermal protection to the stream, but only intermittently and in places where the valley is more constricted. Thermal protection from the forest tends to increase upstream as the valley gets narrower. However, despite a healthy mature cedar/hemlock forest stand, the forest is not an effective source of thermal protection due to the widening of middle Lightning Creek over the years from anthropogenic causes. The widened channel of middle Lightning Creek is mostly devoid of riparian plants (e.g., willow, cottonwood), merely colonizing gravel bars adjacent to the active channel and in the floodplain. Thermal loading to the active floodplain during the summer months, July–September, can be intense. Exacerbating the lack of pioneering riparian species is the lack of large woody debris and a wide, shallow channel. Figure 6 and Figure 7 provide examples of thermal protection in Lightning Creek from Rattle Creek to East Fork Creek.

Figure 8. Examples of moderate to low thermal protection in Lightning Creek.
Photo courtesy of USFS, Sandpoint Ranger Station

Figure 9. Examples of good thermal protection in Lightning Creek.
(Photo courtesy of USFS, Sandpoint Ranger Station)

Lightning Creek from East Fork Creek to Cascade Creek (ID17010213PN013_04)

In 2016, the USFS Sandpoint Ranger Station conducted a survey of lower Lightning Creek from East Fork Creek downstream to the boundary with private property. This was in part to assess the integrity of large wood structures installed in 2015 before a December 2015 high-magnitude rain-on-snow event. The structures were installed to recruit and store woody debris, to influence deposition of coarse and fine substrate, improve stream morphology, enhance recolonization of riparian vegetation, improve bank stability, and improve fish habitat. As part of the project design, several cross sections and photo points were taken as a reference to monitor changes in channel morphology, riparian condition, and large wood abundance. Bank pins were also installed to monitor bank erosion rates. Results of the survey determined some log structures may benefit the thermal regime over time, but the high energy of the reach could compromise structure integrity. Thermal protection was limited due to channel over-widening and lack of riparian vegetation.

Just downstream from East Fork Creek, Lightning Creek was characterized by multiple channels, lacking in large wood, and excessive bedload due to upstream source in East Fork Creek. From 2013–2016, channel widening was evident in the upstream survey reaches. However, large wood recruitment and mid-channel bar formation occurred at several sites resulting in floodplain roughness and increased channel sinuosity. Some large wood structures installed in 2015 remained in place and accumulated wood during the December 2015 high-magnitude rain-on-snow event. Some wood structures were washed out and deposited elsewhere, resulting in beneficial channel changes at those locations. One cross section in the upper reach had its main channel aggraded with bedload above bankfull stage, resulting in the main flow moving into a side channel. This resulted in an increase in sinuosity in this reach and more riparian vegetation on the floodplain.

Downstream of Morris Creek, Lightning Creek has excessive bedload with heavy sourcing from Morris Creek and the steep alluvial valley to the north. Mature trees were falling into this reach due to active bank erosion. One section of the creek has the potential to reach Lightning Creek Road. Six large wood structures were installed in the lower reach in 2015, but only one remained after the December 2015 rain-on-snow event. This is due to the high energy of this reach, which is downstream of a natural alluvial valley constriction. Post-flood evaluations indicated wood structures twice the size of those that were installed would not have withstood the energy created in the 2015 event.

Figure 10. 2013 photopoint (left), 2016 photopoint (right) showing change in channel sinuosity.

Figure 11. 2013 photopoint (left), 2016 photopoint (right) showing bar top structure that washed away.

Figure 12. 2013 photopoint (left), 2016 photopoint (right) Large wood structure compromised in 2015 flood, but floodplain roughness remained to influence riparian vegetation growth.
(Photo courtesy of USFS, Sandpoint Ranger Station)

2.3.4 Status of Beneficial Uses

Updated TMDLs for temperature were calculated for AUs in the Lower Clark Fork River subbasin. Excess temperature can disrupt all life stages of coldwater-dependent fish and affect the COLD beneficial use. Constant temperature exposure to adult fish can result in reduced body weight, reduced oxygen exchange, increased susceptibility to disease, and reduced reproductive capacity. Juvenile fish can experience negative impacts at a lower threshold than adult fish, including slower growth rates. High water temperatures can also affect the development of fish, while still in the egg, before emerging from the stream substrate (Chen, Todd, Murphy, Lomnicky 2016).

2.3.5 Assessment Unit Summary

A summary of the data analysis, literature review, and field investigations and a list of conclusions for AUs included in Category 4a of the 2018-2020 Integrated Report follows. This section includes changes that will be documented in the next Integrated Report once the TMDLs in this document have been approved by EPA.

Assessment Units Addressed in TMDLs

ID17010213PN002_02, Johnson Creek – source to mouth

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN002_03, **Johnson Creek – source to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN004_02, **Twin Creek – 1st/2nd order Twin and Delyle Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN004_02a, **Dry Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN004_03, **Twin Creek – Delyle Creek to Clark Fork River**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN009_02, **Mosquito Creek – source to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN010_04, **Lightning Creek – Spring Creek to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5), despite lack of shade being less than 10%.

ID17010213PN011_04, **Lightning Creek – Cascade Creek to Spring Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN012_02, **Cascade Creek – source to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN013_02, **Lightning Creek – East Fork Creek to Cascade Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN013_04, **Lightning Creek – East Fork Creek to Cascade Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5), despite lack of shade being less than 10%.

ID17010213PN014_02, **East Fork Creek – Idaho/Montana border to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).
- 2016 BURP data did not receive a passing score. The AU's average index score was 1.67.

ID17010213PN014_03, **East Fork Creek – Idaho/Montana border to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).
- 2015 BURP data did not receive a passing score. The AU's average index score was 1.50.

ID17010213PN015_02, **Savage Creek – Idaho/Montana border to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).
- USFS information indicates that Savage Creek is mostly a roadless area with one trail that has no impact on the stream. Old USFS roads have naturally decommissioned over time. Old clear cuts have been reclaimed by forest regeneration.

ID17010213PN016_02, **Tribs to Lightning Creek between Wellington Creek and E. Fork Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN016_03, **Lightning Creek – Wellington Creek to East Fork Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show low excess thermal loading (2%) and shade conditions within the shade target class of <10%. The AU's thermal protection is limited due to:
  - Over-widened/shallow water condition of the channel
  - Unstable gravel bars, which are largely devoid of riparian vegetation (Section 2.3.3), adjacent to the channel. The temperature impairment should not be delisted from Idaho's Integrated Report until thermal protection is improved.

ID17010213PN017_02, **Lightning Creek – Tribs between Wellington Creek & Rattle Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN017_03, **Lightning Creek – Rattle Creek to Wellington Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN018_02, **Rattle Creek – source to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN019_02, **Lightning Creek – source to Rattle Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN019_03, **Lightning Creek – source to Rattle Creek**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

ID17010213PN020_02, **Wellington Creek – source to mouth**

- Listed for Temperature.
- Listed in Category 4a with an approved temperature TMDL.
- 2007 TMDL used different shade curves and requires new TMDLs.
- Data show excess solar loading and solar load allocation (Section 5).

3 Pollutant Source Inventory

Pollution within the Lower Clark Fork River subbasin is primarily from sedimentation/siltation and water temperature. Load allocations were established in the *Lower Clark Fork River Subbasin Assessment and Total Maximum Daily Loads* (DEQ, 2007), for sedimentation/siltation and water temperature.

Excess sediment in the substrate of a stream decreases natural hydrologic functionality and restricts habitat for aquatic wildlife. Vegetative cover holds streambanks together with root masses, but unstable, eroding streambanks suffer from vegetation loss. Without this cover to provide shade, solar radiation to the water surface increases the temperature of the stream and forces aquatic wildlife to seek out alternative, cooler habitats.

3.1 Point Sources

Point sources of pollution are affiliated with known discrete discharges into waters of the United States. In 2018, EPA approved the Idaho Pollutant Discharge Elimination System (IPDES) Program and authorized the transfer of permitting authority to the state. DEQ's IPDES Program is following a phased schedule to assume regulatory authority over point source discharges that include municipal, industrial, storm water, pretreatment controls for certain discharges to publicly owned treatment works, and the sewage sludge (biosolids) management program. DEQ is approved to administer the IPDES Program through the Clean Water Act and the "Rules Regulating the Idaho Pollutant Discharge Elimination System Program" (IDAPA 58.01.25).

The AUs being evaluated for PNV are not affected by the discharge of any IPDES-permitted point sources. No wasteload allocations have been developed in this document.

3.2 Nonpoint Sources

This TMDL establishes TMDL targets at instream conditions under the natural level of shade, channel width, and/or natural vegetation potential. Therefore, the load allocation is set to achieve background riparian shade conditions. To reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade. Load allocations are stream segment specific and dependent on the given segment's target load. This target load (i.e., load capacity) is necessary to achieve background conditions. Shade cannot be removed from the stream without exceeding its load capacity. Additionally, because this TMDL is dependent on background conditions for achieving water quality standards, all tributaries examined here must reflect natural conditions to prevent excess heat loads to the system.

3.3 Pollutant Transport

Pollutant transport refers to the pathway by which pollutants move from the pollutant source to the receiving water body and can cause water quality violations. In the case of temperature, most pollutant transport to small order streams is direct solar radiation exposure.

4 Summary of Pollution Control Efforts and Monitoring

The original shade conditions on perennial water bodies were examined in the Lower Clark Fork River subbasin, the results of which are presented in Section 5.1. Shade conditions were evaluated through interpreting aerial photos from the 2017 National Agricultural Imagery Program. Solar Pathfinder monitoring of shade took place in August 2018 at thirteen sites in the watershed for the purpose of calibrating and enhancing the aerial interpretation.

Excess solar loads from the 2007 Lower Clark Fork River Subbasin Assessment were reviewed to determine if it was possible to identify general trends for solar loads and stream shade in the subbasin. The 2007 subbasin assessment and TMDL did identify AUs and tributaries in a similar fashion to the analysis completed for this TMDL effort. Some small differences were noted in the identification of perennial reaches to include in the different analyses. Assessment unit groupings were matched as closely as possible from 2007 to 2019 to help identify any apparent trends in stream shading. Differences in the shade curves used in the analyses were substantial enough to not allow for a comparison of excess solar loads calculations between the 2007 and 2019 data analysis. Neither the 2007 nor the 2019 analysis consistently over or under reported excess shade or the reductions necessary in solar load to meet shade target levels.

4.1 United States Forest Services Projects

The following projects were implemented since the 2007 TMDL by the USFS.

Lightning Creek – East Fork Creek to Cascade Creek (ID17010213PN013_04), Lightning Creek – Wellington Creek to East Fork Creek (ID17010213PN016_03)

In September 2015, the Lightning Creek Large Wood Enhancement Project was completed in this reach of Lightning Creek. Objectives of the project were to recruit and store woody debris, influence deposition of coarse and fine substrate, enhance recolonization of riparian vegetation, improve bank stability, and increase fish habitat complexity. Bar apex structures were designed to recruit large wood using large logs securely anchored in the upstream apex of gravel bars. Bar top structures were built with large wood rootwads into the streambank to create slack-water conditions desirable for migrating fish. Meander structures were designed to fortify banks on the outside meander bend. Before project implementation, the USFS used cross-sectional surveys, bank pins, and photo points as references to monitor future changes in channel morphology, riparian vegetation responses, and abundance of in-channel large wood. In December 2015, there was a short-duration, high-magnitude rain-on-snow event occurred that altered channel flows. During this event, flows increased from 755 cfs to 6,440 cfs in a 24-hour period. As a result of these flows, some structures of the enhancement project remained in place and operated as designed, while some structures were compromised or washed out completely. Some washed-out log structures redeposited downstream and caused beneficial morphological changes in the channel.

East Fork Creek (ID17010213PN014_03)

In 2009, East Fork Lightning Creek Bridge was replaced to improve access and mitigate risk for erosion and structure failure. Large wood was also installed in point bars to promote riparian vegetation and improve fish habitat.

In 2010, large wood structures were installed during channel restoration projects. The December 2015 flood washed away some of the structures, but some remained intact and are functioning as designed.

In 2011, USFS roads #1184 (with full/partial obliteration and deep ripping) and #1030 (with partial obliteration and scarification) had eight miles of road decommissioned and both roads were converted to nonmotorized trails. USFS road #212 was also decommissioned (with full/partial obliteration and deep ripping).

Savage Creek (ID17010213PN015_02)

Savage Creek is essentially a roadless area with one trail that has no impact on the stream. Older USFS roads have been decommissioned over time.

Porcupine Creek, Mudd Creek, Mink Creek (ID17010213PN016_02)

In 2009, 1.4 miles of USFS road #399 in the Porcupine Creek drainage was decommissioned (with several high-risk culverts removed). USFS road #642 was converted to a motorized trail (with removal of culverts, addition of hardened stream crossings, removal of a CXT toilet, and improved drainage to Lake Pend Oreille). Also removed was the USFS road #642 bridge at Lightning Creek.

In 2012, USFS road #340 in the Mudd/Mink Creek drainages was decommissioned (with full/partial obliteration and deep ripping) and converted to a non-motorized trail.

Rattle Creek (ID17010213PN018_02)

In 2009, the lower 3,100 feet of USFS road #473 was decommissioned (with full obliteration), and streambanks were stabilized and revegetated. In 2010, USFS road #473 was decommissioned (with full obliteration and deep ripping) upstream of the 2009 reach to the bridge. Upstream of the bridge to Clatter Creek, USFS road #473 was decommissioned (with full/partial obliteration and removal of all culverts) and converted to a non-motorized trail.

Quartz Creek, Smorgasbord Creek (ID17010213PN019_02)

In 2012, USFS road #419A was decommissioned in the Quartz Creek drainage (with full/partial obliteration and deep ripping), and USFS road #419 culvert was replaced with a bottomless arch pipe.

In 2012, USFS roads #1091B and #1091C were decommissioned in the Smorgasbord Creek drainage (with blasting to remove all culverts).

Wellington Creek (ID17010213PN020_02)

In 2012, USFS roads #1054, #1054B, and #1016 (and associate spurs) were decommissioned (with full/partial obliteration and deep ripping). USFS roads #1006, #1006A, and #1053 were also decommissioned (with blasting to remove all culverts).

Mainstem Lightning Creek (ID17010213PN013_04, ID17010213PN016_03, ID17010213PN017_03, ID17010213PN019_03, ID17010213PN019_02)

In 2009, 3,250 feet of USFS road #419, Lightning Creek Road, was rerouted at mileposts 14.2, 13.1, and 5.0 and streambanks were stabilized and revegetated. Road washouts were fixed with new culverts, bank repair with large wood, and rock armoring.

In 2017, portions of Lightning Creek Road that were damaged in the December 2015 rain-on-snow event were repaired between mile posts 9.0 and 14.3. This included road realignment of USFS road #419, replacement or improvement of culverts at five locations along the 419, bridge rehabilitation of the 419 bridge over Rattle Creek, and bridge rehabilitation of the 489 bridge over Lightning Creek.

5 Total Maximum Daily Loads

A TMDL prescribes an upper limit (i.e., load capacity) on discharge of a pollutant from all sources to ensure water quality standards are met. It further allocates this load capacity among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation, and nonpoint sources, each of which receives a load allocation. Natural background contributions, when present, are considered part of the load allocation but are often treated separately because they represent a part of the load not subject to control. Because of uncertainties about quantifying loads and the relation of specific loads to attaining water quality standards, the rules regarding TMDLs (40 CFR Part 130) require a margin of safety be included in the TMDL. Practically, the margin of safety and natural background are both reductions in the load capacity available for allocation to pollutant sources.

Load capacity can be summarized by the following equation:

$$LC = MOS + LA + WLA = TMDL$$

Where:

LC = load capacity; target solar load (kWh/day).

MOS = margin of safety; implicit in the PNV method, no separate allowance identified.

LA = load allocation; stream segment dependent based on existing and target solar loads.

WLA = wasteload allocation; no point sources present in subbasin, no separate allowance identified for any TMDLs in this document.

The equation is written in this order because it represents the logical order in which a load analysis is conducted. First, the load capacity is determined. Then the load capacity is broken down into its components. After the necessary margin of safety and natural background, if relevant, are quantified, the remainder is allocated among pollutant sources (i.e., the load allocation and wasteload allocation). When the breakdown and allocation are complete, the result is a TMDL, which must equal the load capacity.

The load capacity must be based on critical conditions—the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determining critical conditions can be complicated.

Another step in a load analysis is quantifying current pollutant loads by source. This step allows for the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary for pollutant trading to occur. A load is fundamentally a quantity of pollutant discharged over some period of time and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary (40 CFR 130.2). These other measures must still be quantifiable and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 Instream Water Quality Targets

For the Lower Clark Fork River subbasin temperature TMDLs, we utilized a PNV approach. The Idaho water quality standards include a provision (IDAPA 58.01.02.200.09) that if natural conditions exceed numeric water quality criteria, exceedance of the criteria is not considered a violation of water quality standards. In these situations, natural conditions essentially become the water quality standard, and for temperature TMDLS, the natural level of shade and channel width become the TMDL target. The instream temperature that results from attaining these conditions is consistent with the water quality standards, even if it exceeds numeric temperature criteria. See Appendix B for further discussion of water quality standards and natural background provisions.

The PNV approach is described briefly below. The procedures and methodologies to develop PNV target shade levels and to estimate existing shade levels are described in detail in *The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual* (Shumar & De Varona, 2009). The manual also provides a more complete discussion of shade and its effects on stream water temperature.

5.1.1 Factors Controlling Water Temperature in Streams

There are several important contributors of heat to a stream, including ground water temperature, air temperature, and direct solar radiation (Poole & Berman, 2001). Of these, direct solar radiation is the source of heat that is most controllable. The parameters that affect the amount of solar radiation hitting a stream throughout its length are shade and stream morphology. Shade is provided by the surrounding vegetation and other physical features such as hillsides, canyon walls, terraces, and high banks. Stream morphology (i.e., structure) affects riparian vegetation density and water storage in the alluvial aquifer. Riparian vegetation and channel morphology are the factors influencing shade that are most likely to have been influenced by anthropogenic activities and can be most readily corrected and addressed by a TMDL.

Riparian vegetation provides a substantial amount of shade on a stream by virtue of its proximity. However, depending on how much vertical elevation surrounds the stream, vegetation further away from the riparian corridor can also provide shade. We can measure the amount of shade that a stream receives in a number of ways. Effective shade (i.e., that shade provided by all objects that intercept the sun as it makes its way across the sky) can be measured in a given location with a Solar Pathfinder or with other optical equipment similar to a fish-eye lens on a camera. Effective shade can also be modeled using detailed information about riparian plants and their communities, topography, and stream aspect.

In addition to shade, canopy cover is a similar parameter that affects solar radiation. Canopy cover is the vegetation that hangs directly over the stream and can be measured using a densiometer or estimated visually either on-site or using aerial photography. All of these methods provide information about how much of the stream is covered and how much is exposed to direct solar radiation.

5.1.2 Potential Natural Vegetation for Temperature TMDLs

PNV along a stream is that riparian plant community that could grow to an overall mature state, although some level of natural disturbance is usually included in the development and use of shade targets. Vegetation can be removed by disturbance either naturally (e.g., wildfire, disease/old age, wind damage, wildlife grazing) or anthropogenically (e.g., domestic livestock grazing, vegetation removal, erosion). The idea behind PNV as targets for temperature TMDLs is that PNV provides a natural level of solar loading to the stream without any anthropogenic removal of shade-producing vegetation. Vegetation levels less than PNV (with the exception of natural levels of disturbance and age distribution) result in the stream heating up from anthropogenically created additional solar inputs.

We can estimate PNV (and therefore target shade) from models of plant community structure (shade curves for specific riparian plant communities), and we can measure or estimate existing canopy cover or shade. Comparing the two (target and existing shade) tells us how much excess solar load the stream is receiving and what potential exists to decrease solar gain. Streams disturbed by wildfire, flood, or some other natural disturbance will be at less than PNV and require time to recover. Streams that have been disturbed by human activity may require additional restoration above and beyond natural recovery.

Existing and PNV shade was converted to solar loads from data collected on flat-plate collectors at the nearest National Renewable Energy Laboratory (NREL) weather stations collecting these data. In this case, we used the Spokane, WA station. The difference between existing and target solar loads, assuming existing load is higher, is the load reduction necessary to bring the stream back into compliance with water quality standards (Appendix B).

PNV shade and the associated solar loads are assumed to be the natural condition; thus, stream temperatures under PNV conditions are assumed to be natural (so long as no point sources or other anthropogenic sources of heat exist in the watershed) and are considered to be consistent with the Idaho water quality standards, even if they exceed numeric criteria by more than 0.3 °C.

Existing Shade Estimates

Existing shade was estimated for twenty-two AUs from visual interpretation of aerial photos. Estimates of existing shade based on plant type and density were marked out as stream segments on a 1:100,000 or 1:250,000 hydrography taking into account natural breaks in vegetation density. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. Each segment was assigned a single value representing the bottom of a 10% shade class (adapted from the cumulative watershed effects process, IDL 2000). For example, if shade for a particular stream segment was estimated somewhere between 50% and 59%, we assigned a 50% shade class to that segment. The estimate is based on a general intuitive observation about the kind of vegetation present, its density, and stream width. Streams where the banks and water are clearly visible are usually in low shade classes (10%, 20%, or 30%). Streams with dense forest or heavy brush where no portion of the stream is visible are usually in high shade classes (70%, 80%, or 90%). More open canopies where portions of the stream may be visible usually fall into moderate shade classes (40%, 50%, or 60%).

Visual estimates made from aerial photos are strongly influenced by canopy cover and do not always take into account topography or any shading that may occur from physical features other than vegetation. It is not always possible to visualize or anticipate shade characteristics resulting from topography and landform. However, research has shown that shade and canopy cover measurements are remarkably similar (OWEB 2001), reinforcing the idea that riparian vegetation and objects proximal to the stream provide the most shade. The visual estimates of shade in this TMDL were partially field verified with a Solar Pathfinder, which measures effective shade and takes into consideration other physical features that block the sun from hitting the stream surface (e.g., hillsides, canyon walls, terraces, and man-made structures).

Solar Pathfinder Field Verification

The accuracy of the aerial photo interpretations was field verified with a Solar Pathfinder at thirteen sites. The Solar Pathfinder is a device that allows one to trace the outline of shade-producing objects on monthly solar path charts. The percentage of the sun's path covered by these objects is the effective shade on the stream at the location where the tracing is made. To adequately characterize the effective shade on a stream segment, twenty traces are taken at systematic or random intervals along the length of the stream in question.

Each Site ID listed in Table 6 represents twenty traces, spaced 25 paces apart on 1st and 2nd order streams and 50 paces apart on 3rd order streams, taken following the manufacturer's instructions (i.e., orient to south and level). At each trace location, the Solar Pathfinder was placed in the middle of the stream at about the bankfull water level. Systematic sampling was used because it is easiest to accomplish without biasing the sampling location. The shade data collected for these twenty traces was averaged and represents the average shade percent for that segment, titled Pathfinder Measurement in Table 6. This Pathfinder Measurement was assigned a single value representing the bottom of a 10% shade class, Pathfinder Classification in Table 6.

When possible, the sampler also measured bankfull widths, took notes, and photographed the landscape of the stream at several unique locations while taking traces. Special attention was given to changes in riparian plant communities and what kinds of plant species (the large, dominant, shade-producing ones) were present. One can also take densiometer readings at the same location as Solar Pathfinder traces. These readings provide the potential to develop relationships between canopy cover and effective shade for a given stream.

Table 6 presents the Solar Pathfinder field verification of aerial photo interpretation for the Lower Clark Fork River subbasin. Overall, the aerial interpretations matched very favorably with data collected with the Solar Pathfinders. Stream shade for the subbasin was slightly underestimated with a mean difference between estimated and measured shade at -0.15. Most measured shade values were within the same shade class or one shade class away from the estimated value.

Table 6. Solar Pathfinder field verification results for the Lower Clark Fork River subbasin.

Stream	AU	Site ID	Aerial Class	Pathfinder Measurement	Pathfinder Class	Class Difference
Dry Creek	ID17010213PN004_02a	DRYCRE_01	80	95	90	-1
East Fork Creek	ID17010213PN014_03	EFOCRE_01	10	32	30	-2
East Fork Creek	ID17010213PN014_02	EFOCRE_02	70	56	50	2
Johnson Creek	ID17010213PN002_02	JOHCRE_01	80	87	80	0
Lightning Creek	ID17010213PN016_03	LIGCRE_01	40	51	50	-1
Lightning Creek	ID17010213PN017_03	LIGCRE_02	50	47	40	1
Lightning Creek	ID17010213PN019_02	LIGCRE_03	60	69	60	0
Mosquito Creek	ID17010213PN009_02	MOSCRE_01	90	95	90	0
Porcupine Creek	ID17010213PN016_02	PORCRE_01	50	76	70	-2
Quartz Creek	ID17010213PN019_02	QUACRE_01	70	83	80	-1
Savage Creek	ID17010213PN015_02	SAVCRE_01	90	80	80	1
Twin Creek	ID17010213PN004_02	TWICRE_01	90	88	80	1
Wellington Creek	ID17010213PN020_02	WELCRE_01	80	80	80	0
				Mean		-0.15
				Standard Deviation		1.17
				Confidence Level (95.0%)		0.63

Target Shade Determination

PNV targets were determined from an analysis of probable vegetation at the streams and comparing that to shade curves developed for similar vegetation communities in Idaho (Shumar & De Varona, 2009). A shade curve shows the relationship between effective shade and stream width. As a stream gets wider, shade decreases as vegetation has less ability to shade the center of wide streams. As the vegetation gets taller, the more shade the plant community can provide at any given channel width.

Natural Bankfull Widths

Stream width must be known to calculate target shade since the width of a stream affects the amount of shade the stream receives. Bankfull width is used because it best approximates the width between the points on either side of the stream where riparian vegetation starts. Measures of current bankfull width may not reflect widths present under PNV (i.e., natural widths). As impacts to streams and riparian areas occur, width-to-depth ratios tend to increase such that streams become wider and shallower. Shade produced by vegetation covers a lower percentage of the water surface in wider streams, and widened streams can also have less vegetative cover if shoreline vegetation has eroded away.

Since, existing bankfull width may not be discernible from aerial photo interpretation and may not reflect natural bankfull widths, this parameter must be estimated from available information. We used regional curves for the major basins in Idaho—developed from data compiled by Diane Hopster of the Idaho Department of Lands—to estimate natural bankfull width (Figure 13).

For each stream evaluated in the load analysis, natural bankfull width was estimated based on the drainage area of the Pend Oreille Basin curve from Figure 13. Regional curves for the major basins in Idaho were developed from data compiled by Diane Hopster of the Idaho Department of Lands to estimate the natural bankfull width. As a function of drainage area, the bankfull width is assumed to be natural. Although estimates from other curves were examined (i.e., Spokane River Basin), the Pend Oreille Basin curve was ultimately chosen because of its proximity to the Lower Clark Fork River watershed. Existing width data collected as part of DEQ's BURP data collection were also evaluated and compared to these curve estimates.

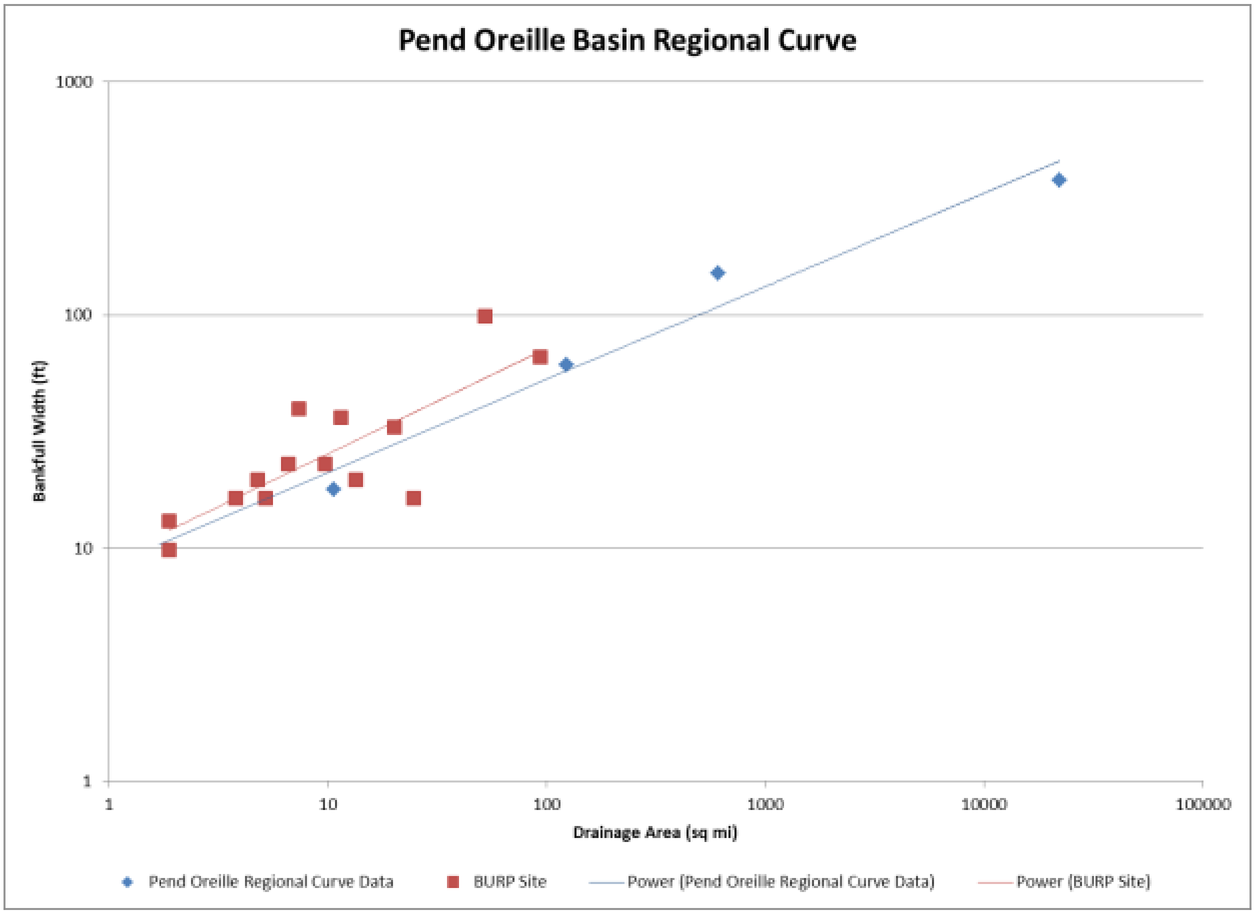

Figure 13. Bankfull width as a function of drainage area.

The existing bankfull width from the BURP data indicates the streams are wider than the natural bankfull width estimates from the Pend Oreille Basin curve. The over-widening of streams opens the streambank tree canopy and decreases available shade. Natural bankfull width estimates for each stream in this analysis are presented in Table C2. The load analysis tables contain a natural bankfull (target) width and an existing bankfull width for every stream segment in the analysis based on the bankfull width results presented in Table and Watershed Advisory Group input.

Most forested sections of the subbasin appear to be mature forest with little to no sign of logging or clearing for roads. In general, old clearcuts have largely been reclaimed by forest regeneration and many roads have been decommissioned (Figure 14) to decrease road density

(Section 4.1). Excess solar loads still exist throughout the subbasin, and stream over-widening could be a primary factor.

Figure 14. Decommissioned Rattle Creek Road at Lightning Creek Road

5.1.3 Design Conditions

The Lower Clark Fork River subbasin is found in the Northern Rockies Level III Ecoregion (McGrath, et al., 2001). Several Level IV ecoregions are found occupying distinct landforms within the subbasin. The majority of the subbasin is found in the Purcell-Cabinet-North Bitterroot Mountains. This ecoregion is typified by having rugged mountains with steep slopes, peaks, ridges with narrow valleys, and few lakes. The Purcell-Cabinet-North Bitterroot Mountains ecoregion holds several different tree species, but can be generally described as having mostly cedar/hemlock/pine forests with spruce/fir forests in higher elevations. Cottonwood, birch, and aspen grow in riparian zones and moist upland sites.

Other Level IV ecoregions in the subbasin include High Northern Rockies on mountain tops and the Inland Maritime Foothills and Valleys along the Clark Fork River. In the hills south of the Clark Fork River, the predominant Northern Rockies Level IV ecoregion is the Coeur d’Alene Metasedimentary Zone (McGrath, et al., 2001).

5.1.4 Shade Curve Selection

PNV shade targets for the Lower Clark Fork River subbasin were determined by examining effective shade curves (Shumar, De Varona, 2009) (Table 7). For the Lower Clark Fork River subbasin, curves for the most similar vegetation type were selected for shade target determinations.

Table 7. Shade target curves used in analysis.

Idaho Forest Types	Idaho Non-Forest Type
Kaniksu – Group B Moist Forest	Panhandle Non-Forest Riparian Group 1 Hardwoods
Kaniksu – Group C Cool Moist Forest	
Kaniksu – Group D Cool Dry Forest	

Three different forest types were identified in the Lower Clark Fork River subbasin. The Kaniksu – Group B Moist Forest was the most predominant forest in the subbasin at low-to-mid elevations in stream bottoms and adjacent benches and toe slopes. This forest type contains a diverse mix of tree species but is dominated by western white pine and western larch. Stands of Douglas-fir and western red cedar are also relatively common in this forest type (Shumar & De Varona, 2009). Forest Groups C and D are higher elevation forests with a less diverse mix of tree species.

The Panhandle Non-Forest Riparian Group 1 Hardwoods type is found in valley bottoms of streams that are designated as 5th order or less with a stream gradient of less than 3%. Within the Lower Clark Fork River subbasin, only portions of Lightning Creek downstream of Rattle Creek to the Clark Fork River can be defined within these parameters. This grouping includes a mix of coniferous and deciduous tree and shrub species. Figure 15 shows the relative composition of tree and shrub species found within Group 1. Shade curves used to determine targeted shade values are presented in Figure C1. Lower Clark Fork River subbasin Kaniksu – Group B forest type shade curve through Figure C4 in Appendix C.

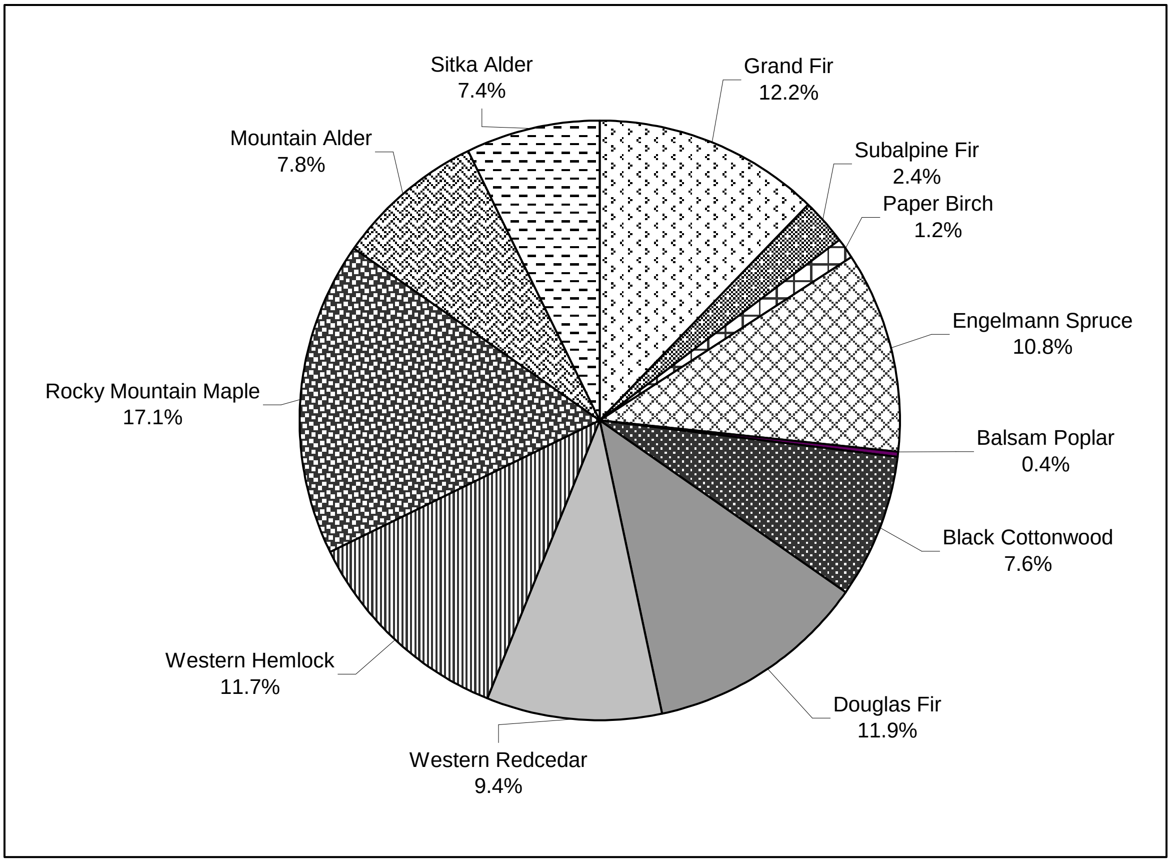

Figure 15. Relative species composition of Group 1 Hardwoods (DEQ, 2013).

5.2 Load Capacity

The load capacity for a stream under PNV is essentially the solar loading allowed under the shade targets specified for the segments within that stream. These loads are determined by multiplying the solar load measured by a flat-plate collector (under full sun) for a given period of time by the fraction of the solar radiation that is not blocked by shade (i.e., the percent open or 100% minus percent shade). In other words, if a shade target is 60% (or 0.6), the solar load hitting the stream under that target is 40% of the load hitting the flat-plate collector under full sun. The target solar load for each segment identified is then summed to determine the target solar load for the entire AU. The target solar load can be summarized with the following equation:

$$\sum seg = seg_1 + seg_2 + seg_3 + \cdots + seg_n$$

Where:

seg = $NREL\ Collector\ \frac{\frac{kWh}{m^2}}{day} \times \ (1\ - Target\ Shade\ Percentage) \times\ seg\ area\ m^2$

(seg area m^2 derived from Appendix C)

We obtained solar load data from flat-plate collectors at the NREL weather station in Spokane, WA. The solar load data used in this TMDL analysis are spring/summer averages (i.e., an average load for the 6-month period from April through September). As such, load capacity calculations are also based on this 6-month period, which coincides with the time of year when stream temperatures are increasing, deciduous vegetation is in leaf, and has the potential to overlap spring and fall spawning periods. During this period, temperatures may affect beneficial uses such as spring and fall salmonid spawning and cold water aquatic life (COLD) criteria may be exceeded during summer months. Late July and early August typically represent the period of highest stream temperatures. However, solar gains can begin early in the spring and affect not only the highest temperatures reached later in the summer but also salmonid spawning temperatures in spring and fall.

Table C3 through Table C23 in Appendix C and Figure 16 show the PNV shade targets. The tables also show corresponding target summer loads (in kilowatt-hours per square meter per day [kWh/m^2/day] and kWh/day) that serve as the load capacities for the streams. Existing and target loads in kWh/day can be summed for the entire stream or portion of stream examined in a single load analysis table. These total loads are shown at the bottom of their respective columns in each table. Because load calculations involve stream segment area calculations, the segment's channel width, which typically only has one or two significant figures, dictates the level of significance of the corresponding loads. One significant figure in the resulting load can create rounding errors when existing and target loads are subtracted. The totals row of each load table represents total loads with two significant figures to reduce apparent rounding errors.

The AU with the largest target load (i.e., load capacity) was Lightning Creek – East Fork Creek to Cascade Creek (AU ID17010213PN013_04) with 910,000 kWh/day (Table C12). The smallest target load was in the Lightning Creek – tribs between Wellington & Rattle Creek (AU ID17010213PN017_02) with 910 kWh/day (Table C18).

5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (40 CFR 130.2(g)). The existing solar load for each segment identified is then summed to determine the existing solar load for the entire AU. The existing solar load can be summarized with the following equation:

$$\sum seg = seg_1 + seg_2 + seg_3 + \cdots + seg_n$$

Where:

seg = $NREL\ Collector\,\frac{\frac{kWh}{m^2}}{day} \times\ (1\ - Existing\ Shade\ Percentage) x seg\ area\ m^2$

Existing loads in this document come from existing shade estimates determined from aerial photo interpretations (Figure 17). There are currently no permitted point sources in the affected AUs that require a wasteload allocation within the scope of this TMDL. Like target shade, existing shade was converted to a solar load by multiplying the fraction of open stream by the solar radiation measured on a flat-plate collector at the NREL weather station in Spokane, WA. Existing shade data are presented in Table C3 through Table C23. Like load capacities (target loads), existing loads in Table C3 through Table C23 are presented on an area basis (kWh/m^2/day) and as a total load (kWh/day). Existing loads in kWh/day are also summed for the entire stream or portion of stream examined in a single load analysis table. The difference between target and existing load is also summed for the entire table. Should existing load exceed target load, the difference becomes the excess load (i.e., lack of shade) to be discussed next in the load allocation section and as depicted in the lack-of-shade figures (Figure 18).

The AU with the largest existing load was Lightning Creek – East Fork Creek to Cascade Creek (AU ID17010213PN013_04) with 1,100,000 kWh/day (Table C12). The smallest existing load was in the Lightning Creek – tribs between Wellington & Rattle Creek AU (AU ID17010213PN017_02) with 9,300 kWh/day (Table C18).

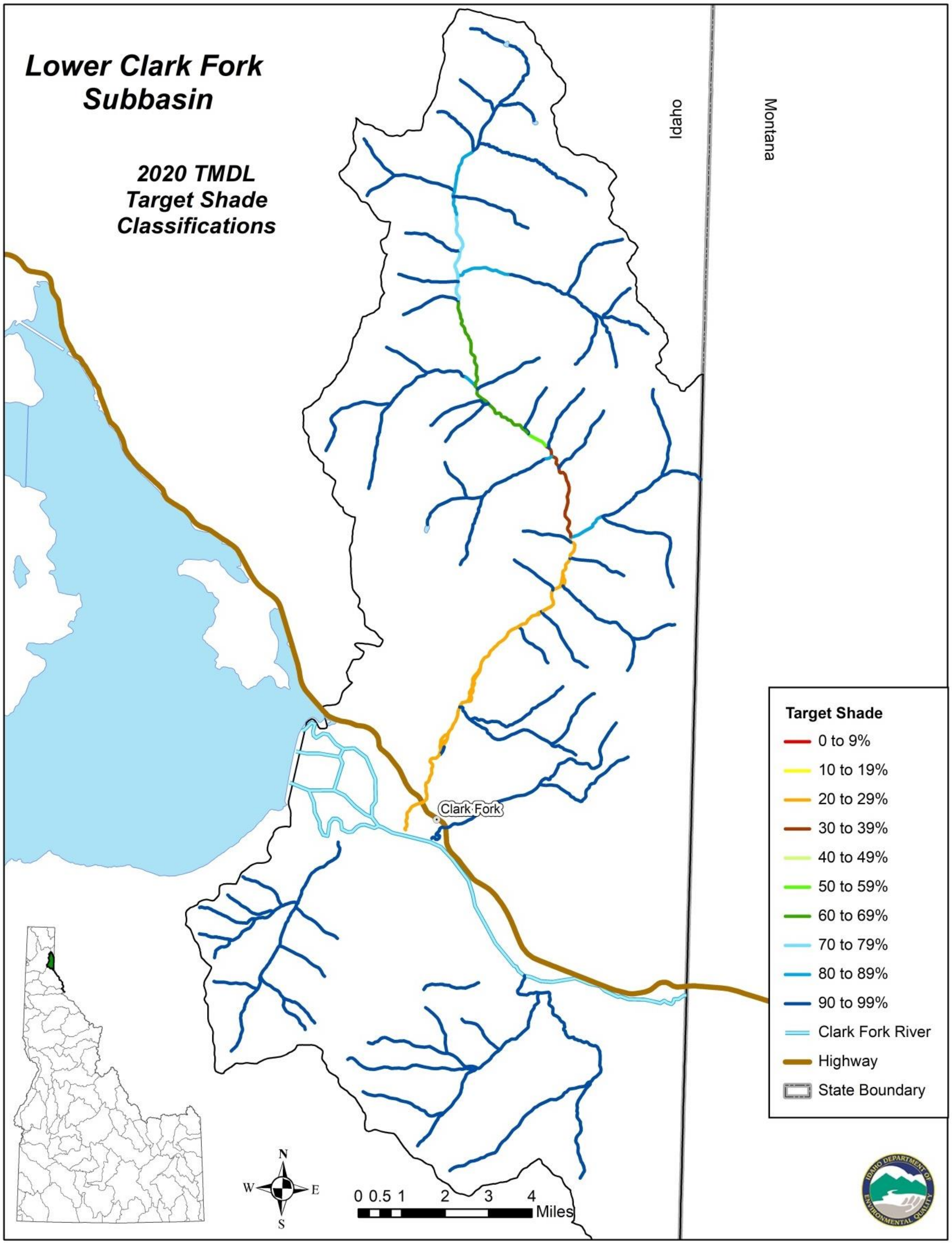

Figure 16. Target shade for Lower Clark Fork River subbasin.

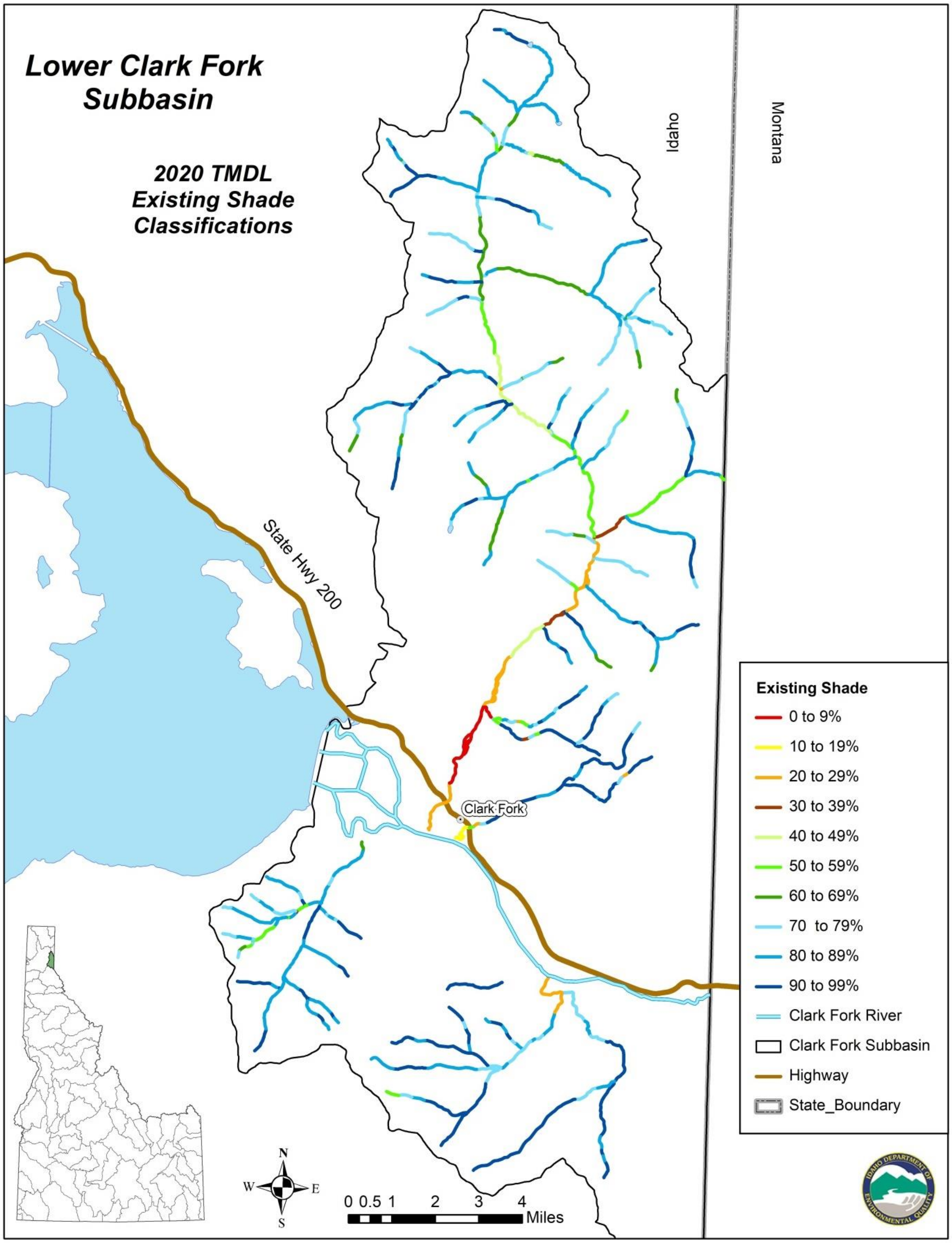

Figure 17. Existing shade estimated for Lower Clark Fork River subbasin by aerial photo interpretation.

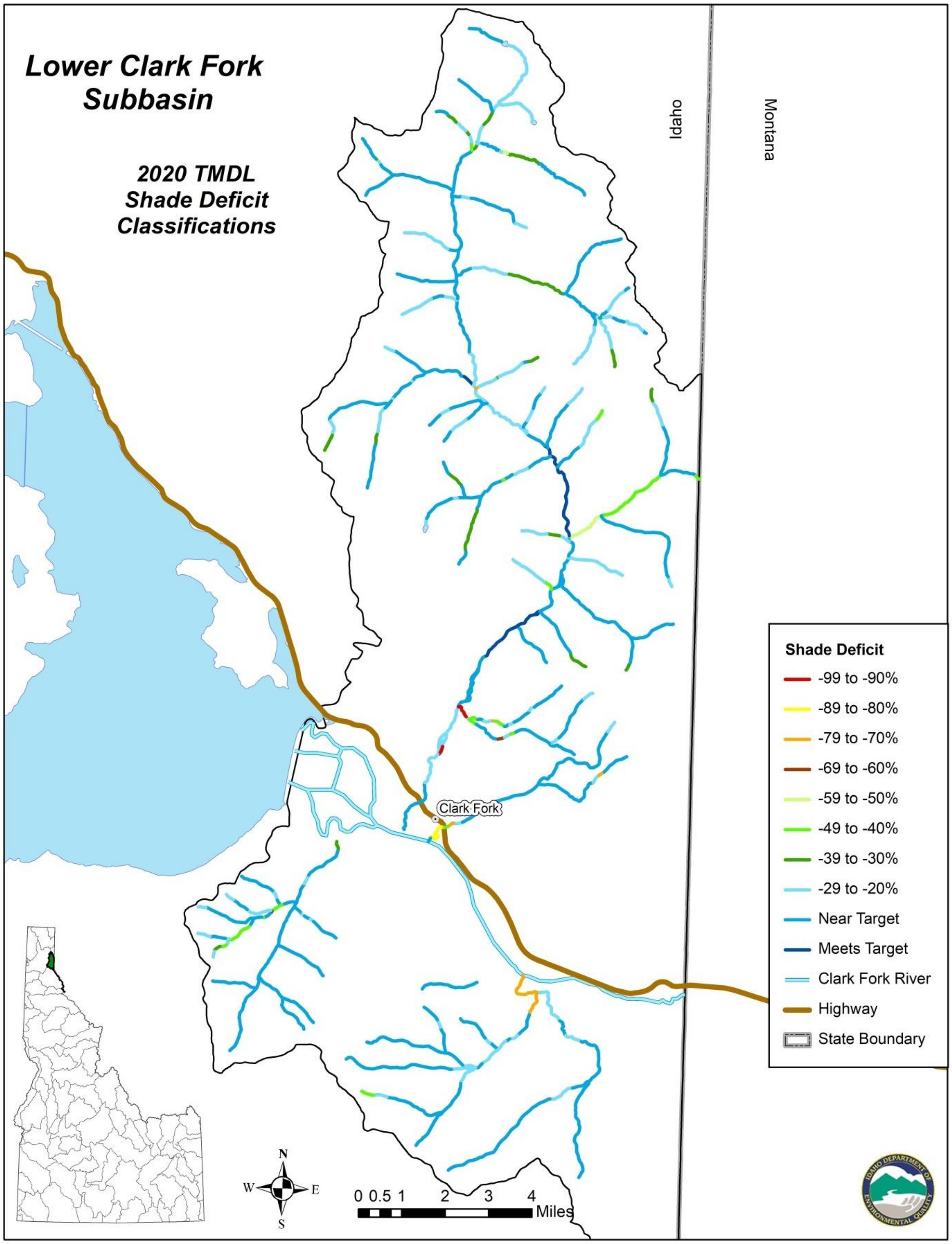

Figure 18. Lack of shade (difference between existing and target) for the Lower Clark Fork River subbasin.

5.4 Load Allocation

Because this TMDL is based on PNV, which is equivalent to background loading, the load allocation is essentially the desire to achieve background conditions. However, in order to reach that objective, load allocations are assigned to nonpoint source activities that have affected or may affect riparian vegetation and shade as a whole. Therefore, load allocations are stream segment specific and dependent upon the target load for a given segment. Table C3 through Table C23 in Appendix C show the target shade and corresponding target summer load. This target load presented in Table 8 is necessary to achieve background conditions and is equivalent to the TMDL or load capacity calculated for each AU. There is no opportunity to further remove shade from the stream by any activity without exceeding its load capacity. Additionally, because this TMDL is dependent upon background conditions for achieving water quality standards, all tributaries to the waters examined here need to be in natural conditions to prevent excess heat loads to the system.

Table C3 through Table C23 in Appendix C shows the total existing, target, and excess loads and the average lack of shade for each water body examined. The size of a stream influences the size of the excess load. Large streams have higher existing and target loads by virtue of their larger channel widths. Table C3 through Table C23 in Appendix C lists the AUs in order of their AU number, from lowest to highest.

Although this TMDL analysis focuses on total solar loads, it is important to note that differences between existing and target shade, as depicted in the shade deficit figure (Figure 18), are the key to successfully restoring these waters to achieving water quality standards. Target shade levels for individual reaches should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts. Each load analysis table contains a column that lists the lack of shade on the stream segment. This value is derived from subtracting target shade from existing shade for each segment. Thus, stream segments with the largest lack of shade are in the worst shape. The average lack of shade derived from the last column in each load analysis table is listed in Table 8 and provides a general level of comparison among streams.

Table 8. Total solar loads and average lack of shade for all waters.

Water Body	Assessment Unit	Total Target Load (kWh/day)	Total Existing Load (kWh/day)	Excess Load (% Reduction) (kWh/day)	Average Lack of Shade (%)
Johnson Creek – source to mouth	ID17010213PN002_02	17,000	99,000	83,000 (84%)	-21%
Johnson Creek – source to mouth	ID17010213PN002_03	26,000	36,000	11,000 (31%)	-8%
Twin Creek – 1st & 2nd order Twin & Delyle Creek	ID17010213PN004_02	2,900	27,000	25,000 (93%)	-17%
Dry Creek	ID17010213PN004_02a	4,500	41,000	38,000 (93%)	-15%
Twin Creek – Delyle Creek to Clark Fork River	ID17010213PN004_03	5,800	82,000	77,000 (94%)	-30%
Mosquito Creek – source to mouth	ID17010213PN009_02	8,900	82,000	78,000 (95%)	-26%
Lightning Creek – Spring Creek to mouth	ID17010213PN010_04	230,000	250,000	20,000 (8%)	-3%
Lightning Creek – Cascade Creek to Spring Creek	ID17010213PN011_04	450,000	610,000	160,000 (26%)	-16%
Cascade Creek – source to mouth	ID17010213PN012_02	7,100	67,000	63,000 (94%)	-29%
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_02	6,300	53,000	49,000 (92%)	-20%
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_04	910,000	1,100,000	93,000 (9%)	-2%
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_02	14,000	83,000	70,000 (84%)	-26%
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_03	13,000	60,000	47,000 (78%)	-53%
Savage Creek – Idaho/Montana border to mouth	ID17010213PN015_02	3,100	15,000	13,000 (87%)	-12%
Tribs. To Lightning Cr between Wellington & E. Fork Creek	ID17010213PN016_02	10,000	95,000	88,000 (93%)	-22%
Lightning Creek – Wellington Creek to East Fork Creek	ID17010213PN016_03	390,000	400,000	9,000 (2%)	-8%
Lightning Creek – tribs between Wellington & Rattle Creek	ID17010213PN017_02	910	9,300	9,000 (97%)	-15%
Lightning Creek – Rattle Creek to Wellington Creek	ID17010213PN017_03	110,000	180,000	66,000 (37%)	-17%
Rattle Creek – source to mouth	ID17010213PN018_02	19,000	110,000	93,000 (85%)	-22%
Lightning Creek – source to Rattle Creek	ID17010213PN019_02	26,000	140,000	120,000 (86%)	-21%
Lightning Creek – source to Rattle Creek	ID17010213PN019_03	49,000	82,000	33,000 (40%)	-12%
Wellington Creek – source to mouth	ID17010213PN020_02	13,000	53,000	41,000 (77%)	-15%

Note: Load data are rounded to two significant figures, which may present rounding errors.

Most load reductions required to meet shade targets are quite large—load reductions of 70% or more are common throughout the subbasin. This difference is partially explained by over-widened and to the values of forested shade targets. The highest existing shade class value assigned to a stream is 90%. Forested shade targets, and shade targets of small 1st order streams, generally have shade targets with percent shade values in the mid-90s or higher. When a subbasin has large collections of small, forested streams, the existing solar loads can appear to have large excess loads even if shade values are at or near potential.

A certain amount of excess load is potentially created by the existing shade/target shade difference inherent in the loading analysis. Because existing shade is reported as a 10% shade class and target shade a unique integer between 0 and 100%, there is usually a difference between the two. For example, say a particular stream segment has a target shade of 86% based on its vegetation type and natural bankfull width. If existing shade on that segment were at target level, it would be recorded as 80% in the loading analysis because it falls into the 80% existing shade class. There is an automatic difference of 6%, which could be attributed to the margin of safety.

The percent differences of existing and target solar loads can be large in gross total of solar input yet be functionally closer to targeted shade values if the average lack of shade is considered. The average lack of shade value compares the percent difference between target and existing shade for each identified stream segment and then averages those differences for the entire AU. For example, the second order AU of Savage Creek requires an 87% reduction in solar load to meet its solar load target; however, the average difference between existing shade and target shade is only 12%—close to a mere one shade class away from functioning at potential natural vegetation. Within the subbasin, over half of the AUs (twelve of the 22 AUs) analyzed show similar conditions where the average lack of shade is within one or two shade classes of potential. The average lack of shade is a useful measurement for directing implementation.

5.4.1 Water Diversion

Stream temperature may be affected by diversions of water for water rights purposes. Diversion of flow reduces the amount of water exposed to a given level of solar radiation in the stream channel, which can result in increased water temperature in that channel. Loss of flow in the channel also affects the ability of the near-stream environment to support shade-producing vegetation, resulting in an increase in solar load to the channel.

Although these water temperature effects may occur, nothing in this TMDL supersedes any water appropriation in the affected watershed. Section 101(g), the Wallop Amendment, was added to the CWA as part of the 1977 amendments to address water rights. It reads as follows:

> It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this chapter. It is the further policy of Congress that nothing in this chapter shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall co-operate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.

Additionally, Idaho water quality standards indicate the following:

> The adoption of water quality standards and the enforcement of such standards is not intended to…interfere with the rights of Idaho appropriators, either now or in the future, in the utilization of the water appropriations which have been granted to them under the statutory procedure… (IDAPA 58.01.02.050.01)

In this TMDL, we have not quantified what impact, if any, diversions are having on stream temperature. Water diversions are allowed for in state statute, and it is possible for a water body to be 100% allocated. Diversions notwithstanding, reaching shade targets as discussed in the TMDL will protect what water remains in the channel and allow the stream to meet water quality standards for temperature. This TMDL will lead to cooler water by achieving shade that would be expected under natural conditions and water temperatures resulting from that shade. DEQ encourages local landowners and holders of water rights to voluntarily do whatever they can to help instream flow for the purpose of keeping channel water cooler for aquatic life.

5.4.2 Margin of Safety

The margin of safety in this TMDL is considered implicit in the design. Because the target is essentially background conditions, loads (shade levels) are allocated to lands adjacent to these streams at natural background levels. Because shade levels are established at natural background or system potential levels, it is unrealistic to set shade targets at higher, or more conservative, levels. Additionally, existing shade levels are reduced to the next lower 10% shade class, which likely underestimates actual shade in the loading analysis. Although the loading analysis used in this TMDL involves gross estimations that are likely to have large variances, load allocations are applied to the stream and its riparian vegetation rather than specific nonpoint source activities and can be adjusted as more information is gathered from the stream environment.

5.4.3 Seasonal Variation

This TMDL is based on average summer loads. All loads have been calculated to be inclusive of the 6-month period from April through September. This time period is when the combination of increasing air and water temperatures coincide with increasing solar inputs and vegetative shade. The critical time periods are April through June when spring salmonid spawning occurs, July and August when maximum temperatures may exceed cold water aquatic life criteria, and September when fall salmonid spawning is most likely to be affected by higher temperatures. Water temperature is not likely to be a problem for beneficial uses outside of this time period because of cooler weather and lower sun angle.

5.4.4 Reasonable Assurance

When TMDLs are developed for water bodies that are impaired by point sources only, the issuance of an IPDES permit(s) provides reasonable assurance that the WLA in the TMDL will be achieved. When a TMDL is developed for water bodies impaired by both point and nonpoint sources, the TMDL must provide reasonable assurance that the load allocation will be achieved through nonpoint source controls for the TMDL to be approvable. For water bodies only impaired by nonpoint sources, a demonstration of reasonable assurance is not required (EPA 1992). While a demonstration of reasonable assurance is not required in this TMDL, the State of Idaho relies on the Idaho Nonpoint Source Management Plan, TMDL implementation plans, §319 grants, and agency partners to promote voluntary implementation of nonpoint source controls which may be required to meet a TMDL's load allocation requirements.

Clean Water Act §319 requires each state to develop and submit a nonpoint source management plan. The *Idaho Nonpoint Source Management Plan* was approved by EPA in December 2020 (DEQ 2020. The plan identifies programs to achieve implementation of nonpoint source BMPs, includes a schedule for program milestones, outlines key agencies and agency roles, identifies available funding sources, and is certified by the state attorney general to ensure that adequate authorities exist to implement the plan.

Idaho's nonpoint source management program describes many of the voluntary and regulatory approaches the state will take to abate nonpoint pollution sources. A prominent provision in the plan is for public involvement, including basin advisory groups and WAGs. The Lower Clark Fork Watershed Advisory Group is the designated WAG for the Lower Clark Fork River subbasin.

The Idaho water quality standards refer to existing authorities to control nonpoint pollution sources in Idaho. These authorities and responsible agencies are listed in Table 9.

Table 9. State of Idaho's regulatory authority for nonpoint pollution sources.

Authority	Water Quality Standard	Responsible Agency
Rules Pertaining to the Idaho Forest Practices Act (IDAPA 20.02.01)	58.01.02.350.03(a)	Idaho Department of Lands
Solid Waste Management Rules and Standards (IDAPA 58.01.06)	58.01.02.350.03(b)	Department of Environmental Quality
Individual/Subsurface Sewage Disposal Rules (IDAPA 58.01.03)	58.01.02.350.03(c)	Department of Environmental Quality
Stream channel Alteration Rules (IDAPA 37.03.07)	58.01.02.350.03(d)	Department of Water Resources
Rules Governing Exploration, Surface Mining and Closure of Cyanidation Facilities (IDAPA 20.03.02)	58.01.02.350.03(f)	Idaho Department of Lands
Dredge and Placer Mining Operations in Idaho (IDAPA 20.03.01)	58.01.02.350.03(g)	Idaho Department of Lands
Rules Governing Dairy Waste (IDAPA 02.04.14)	58.01.02.350.03(h)	Idaho State Department of Agriculture
Rathdrum Prairie Sewage Disposal Regulations (Panhandle District Health Department)	58.01.02.350.03(e)	Department of Environmental Quality Panhandle District Health Department

Idaho uses a voluntary approach to address agricultural nonpoint sources; however, regulatory authority is found in the water quality standards (IDAPA 58.01.02.350.01–03). IDAPA 58.01.02.055.07 refers to the Idaho Agricultural Pollution Abatement Plan (Ag Plan) (SCC and DEQ 2015), which provides direction to the agricultural community regarding approved BMPs. A portion of the Ag Plan outlines responsible agencies or elected groups (e.g., soil conservation districts) that will take the lead if nonpoint source pollution problems need to be addressed. For agricultural activity, the Ag Plan assigns the local soil conservation districts to assist the landowner/operator with developing and implementing BMPs to abate nonpoint source pollution associated with the land use. If a voluntary approach does not succeed in abating the pollutant problem, the state may seek injunctive relief for those situations determined to be an imminent and substantial danger to public health or the environment (IDAPA 58.01.02.350.02(a)).

The Idaho water quality standards and wastewater treatment requirements specify that if water quality standards are not being met, even with the use of BMPs or knowledgeable and reasonable practices, the state may request that the designated agency evaluate and/or modify the BMPs to protect beneficial uses. If necessary, the state may seek injunctive or other judicial relief against the operator of a nonpoint source activity in accordance with the DEQ director’s authority provided in Idaho Code §39-108 (IDAPA 58.01.02.350).

The water quality standards list designates agencies responsible for reviewing and revising nonpoint source BMPs:

- Idaho Department of Lands – timber harvest activities, mining activities, and oil/gas exploration and development
- Idaho Soil and Water Conservation Commission – grazing and agricultural activities
- Idaho Transportation Department – public road construction
- Idaho State Department of Agriculture – aquaculture
- DEQ – all other activities (IDAPA 58.01.02.010.24).

5.4.5 Construction Stormwater Allocations

Stormwater runoff is water from rain or snowmelt that does not immediately infiltrate into the ground and flows over or through natural or man-made storage or conveyance systems. When undeveloped areas are converted to land uses with impervious surfaces—such as buildings, parking lots, and roads—the natural hydrology of the land is altered and can result in increased surface runoff rates, volumes, and pollutant loads. Certain types of stormwater runoff are considered point source discharges for Clean Water Act purposes, including stormwater that is associated with municipal separate storm sewer systems (MS4s), industrial stormwater covered under the Multi-Sector General Permit (MSGP), and construction stormwater covered under the Construction General Permit (CGP). For more information about these permits and managing stormwater, see Appendix D.

No known IPDES-permitted point sources exist in the affected watersheds. Thus, no wasteload allocations are discussed in this TMDL. Should a point source be proposed that would have thermal consequences on these waters, background provisions in Idaho water quality standards addressing such discharges (IDAPA 58.01.02.200.09; IDAPA 58.01.02.401.01) must be involved (Appendix B).

5.4.6 Reserve for Growth

There is no nonpoint reserve for growth in these temperature TMDLs. Allocations are based on meeting natural background riparian canopy conditions. However, future discharges may need point source reserve for growth.

A growth reserve has not been included in this TMDL. The load capacity has been allocated to the existing sources in the watershed. Any new sources will need to obtain a load allocation that complies with the TMDL objectives. Should a point source be proposed that would have thermal consequences on these waters, background provisions in Idaho water quality standards addressing such discharges (IDAPA 58.01.02.200.09; IDAPA 58.01.02.401.01) must be involved (Appendix B).

5.5 Wasteload Allocation

No known IPDES-permitted point sources exist in the affected watersheds. Thus, no wasteload allocations are discussed in this TMDL. Should a point source be proposed that would have thermal consequences on these waters, background provisions in Idaho water quality standards addressing such discharges (IDAPA 58.01.02.200.09; IDAPA 58.01.02.401.01) must be involved (Appendix B).

5.6 Protection of Downstream Waters

Consistent with IDAPA 58.01.02.054.04, “there is no impairment of beneficial uses or violations of water quality standards where natural conditions exceed applicable water quality criteria.” Load capacity estimates and load allocations are based on PNV. The goal of PNV-based TMDLs is to attain shade conditions equivalent to natural conditions and achieve a temperature regime expected under natural background conditions. This TMDL uses shade as a surrogate, instead of estimating natural background temperatures, so no numeric temperature target is established. Natural background standards only apply “when natural background conditions exceed any applicable water quality criteria” (IDAPA 58.01.02.200.09). If stream temperatures are below numeric temperature criteria when natural conditions are achieved (i.e., TMDL is fully implemented), natural background standards would not apply; however, if stream temperatures do not exceed numeric criteria when PNV is achieved, there is no longer a temperature impairment to beneficial uses.

Idaho’s water quality standards require that all waters “shall maintain a level of water quality at their pour point into downstream waters that provides for the attainment and maintenance of the water quality standards of those downstream waters, including waters of another state or tribe” (IDAPA 58.01.02.070.08). These TMDLs are developed to achieve stream temperatures equivalent to natural background conditions. If stream temperatures exceed numeric temperature criteria when PNV targets are achieved, and there are no other anthropogenic sources of heat load, the stream temperature is equivalent to natural background temperature or natural conditions (IDAPA 58.01.02.09.209). Allocations are developed to achieve natural background temperatures protective of beneficial uses and would not contribute to downstream temperature impairments.

AUs addressed in this TMDL are tributaries to the Lower Clark Fork River. The Lower Clark Fork River has approved TMDLs for metals (cadmium, copper, and zinc) and dissolved gas supersaturation. The Lower Clark Fork River is within Category 5 of Idaho’s most recent Integrated Report (DEQ, 2020) for temperature impairment. DEQ is evaluating methodologies for developing temperature TMDLs in large rivers in Idaho. DEQ and the EPA are reviewing successful approaches applied in nearby states.

This approach also helps determine the scale of potential impacts from tributary streams to the beneficial uses of the Lower Clark Fork River designated as COLD, domestic water supply, SS, and primary contact recreation.

Additionally, Lightning Creek discharges at the head of the Lower Clark Fork River delta to Lake Pend Oreille. The confluence of Lightning Creek and the river is approximately 2.5 miles from the main body of the lake. The lake is also designated for the same beneficial uses as the river.

5.7 Implementation Strategies

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or significant progress is not being made toward achieving the goals. Reasonable assurance (addressed in section 5.4.4) for the TMDL to meet water quality standards is based on the implementation strategy.

Implementation strategies for TMDLs produced using PNV-based shade and solar loads should incorporate the load analysis tables presented in this TMDL, Table through Table in Appendix C. These tables need to be updated as part of implementation, first to field verify the remaining existing shade levels and second to monitor progress toward achieving reductions and TMDL goals. Using the Solar Pathfinder to measure existing shade levels in the field is important to achieving both objectives. It is likely that further field verification will find discrepancies with reported existing shade levels in the load analysis tables. Due to the inexact nature of the aerial photo interpretation technique, these tables should not be viewed as complete until verified. Implementation strategies should include Solar Pathfinder monitoring to simultaneously field verify the TMDL and mark progress toward achieving desired load reductions. Figure 18, shade deficit classifications, and the natural bankfull/existing bankfull differences are useful tools for focused implementation.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or significant progress is not being made toward achieving the goals. Reasonable assurance (addressed in section 5.4.4) for the TMDL to meet water quality standards is based on the implementation strategy. There may be a variety of reasons that individual stream segments do not meet shade targets, including natural phenomena (e.g., beaver ponds, springs, wet meadows, and past natural disturbances) and/or historic land-use activities (e.g., logging, grazing, and mining). It is important that existing shade for each stream segment be field verified to determine if shade differences are real and result from activities that are controllable. Information within this TMDL (maps and load analysis tables) should be used to guide and prioritize implementation investigations. The information in this TMDL may need further adjustment to reflect new information and conditions in the future.

5.7.1 Time Frame

Implementing the temperature TMDL relies on riparian area BMPS to provide a mature canopy cover to shade the stream and prevent excess solar loading. Because implementation is dependent on mature riparian communities to substantially improve stream temperatures, DEQ believes 10–20 years may be a reasonable amount time for achieving water quality standards. Shade targets will not be achieved all at once. Given their smaller bankfull widths, smaller streams may reach targets sooner than larger streams.

5.7.2 Approach

Funding provided under Clean Water Act §319 and other funds will be used to encourage voluntary projects to reduce nonpoint source pollution.

5.7.3 Responsible Parties

DEQ and the designated management agencies have primary responsibility for overseeing implementation, in cooperation with landowners and managers. In Idaho, these agencies, and their federal and state partners, are charged by the Clean Water Act to lend available technical assistance and other appropriate support to local efforts for water quality improvements. Designated state agencies are responsible for assisting with preparation of specific implementation plans, particularly if they have regulatory authority or programmatic responsibility for those resources:

- Idaho Department of Lands – timber harvest activities, mining activities, and oil/gas exploration and development
- Idaho Soil and Water Conservation Commission – grazing and agricultural activities
- Idaho Transportation Department – public road construction
- Idaho State Department of Agriculture – aquaculture
- DEQ – all other activities (IDAPA 58.01.02.010.24).

In addition to the designated management agencies, the public—when practical through the WAG and other equivalent organizations/processes—may be involved in developing the implementation plan. Public participation will significantly affect public acceptance of the document and the proposed control actions. Stakeholders (e.g., landowners, local governing authorities, taxpayers, industries, land managers) are the most educated regarding the pollutant sources and will be called upon to help identify the most appropriate control actions for each area. Experience has shown that the best and most effective implementation plans are those developed with substantial public cooperation and involvement.

5.7.4 Implementation Monitoring Strategy

The objectives of an implementation monitoring strategy are to validate long-term recovery, better understand natural variability, track project and BMP progress, and track the effectiveness of TMDL. This monitoring and feedback mechanism is a major element of the reasonable assurance component of the TMDL implementation plan.

Monitoring will provide information on progress being made toward achieving TMDL allocations and water quality standards and will help in the interim evaluation of progress, including the development of 5-year reviews and future TMDLs.

The implementation plan will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. Implementation plan monitoring will include watershed and BMP monitoring.

Effective shade monitoring can take place on any segment throughout wadeable streams within the Lower Clark Fork River subbasin and be compared to existing shade estimates seen in Figure 17 and described in Table through Table in Appendix C. Those areas with the largest disparity between existing and target shade should be monitored with Solar Pathfinders to verify existing shade levels and determine progress toward meeting shade targets. Since many existing shade estimates have not been field verified, they may require adjustment during the implementation process. Stream segment length for each estimate of existing shade varies depending on the land use or landscape that has affected that shade level. It is appropriate to monitor within a given existing shade segment to see if that segment has increased its existing shade toward target levels. Twenty equally spaced Solar Pathfinder measurements averaged together within that segment should suffice to determine new shade levels in the future.

5.7.5 Pollutant Trading

Pollutant trading (also known as water quality trading) is a contractual agreement to exchange pollution reductions between two parties. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost-effective, local solutions to problems caused by pollutant discharges to surface waters. Pollutant trading is one of the tools available to meet reductions called for in a TMDL where point and nonpoint sources both exist in a watershed. For additional information, see Appendix E.

6 Conclusions

Effective shade targets were established for 22 AUs, based on maximum shading under PNV, resulting in natural background temperature levels. Shade targets were derived from effective shade curves developed for similar vegetation types in Idaho. Existing shade was determined from aerial photo interpretation and partially field verified with Solar Pathfinder data. Target and existing shade levels were compared to determine the amount of shade needed to bring water bodies into compliance with temperature criteria in Idaho's water quality standards (IDAPA 58.01.02). A summary of assessment outcomes, including recommended changes to listing status in the next Integrated Report, is presented in Table 10.

Table 10. Summary of assessment outcomes.

Water Body	Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to Next Integrated Report	Justification
Johnson Creek – source to mouth	ID17010213PN002_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Johnson Creek – source to mouth	ID17010213PN002_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Twin Creek – 1st & 2nd order Twin & Delyle Creek	ID17010213PN004_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Dry Creek	ID17010213PN004_02a	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Twin Creek – Delyle Creek to Clark Fork River	ID17010213PN004_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Mosquito Creek – source to mouth	ID17010213PN009_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – Spring Creek to mouth	ID17010213PN010_04	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – Cascade Creek to Spring	ID17010213PN011_04	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Cascade Creek – source to mouth	ID17010213PN012_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – East Fork Creek to Cascade Creek	ID17010213PN013_04	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade

Water Body	Assessment Unit	Pollutant	TMDL(s) Completed	Recommended Changes to Next Integrated Report	Justification
East Fork Creek – Idaho/Montana border to mouth	ID17010213PN014_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Savage Creek – Idaho/Montana border to mouth	ID17010213PN015_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Tribs to Lightning Creek between Wellington Creek and E. Fork Creek	ID17010213PN016_02	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – Wellington Creek to East Fork Creek	ID17010213PN016_03	Temperature	Yes	Remain in Category 4a	Excess solar load from lack of shade
Lightning Creek – tribs between Wellington Creek & Rattle Creek	ID17010213PN017_02	Temperature	Yes	Category 4a	Excess solar load from lack of shade
Lightning Creek – Rattle Creek to Wellington Creek	ID17010213PN017_03	Temperature	Yes	Category 4a	Excess solar load from lack of shade
Rattle Creek – source to mouth	ID17010213PN018_02	Temperature	Yes	Category 4a	Excess solar load from lack of shade
Lightning Creek – source to Rattle Creek	ID17010213PN019_02	Temperature	Yes	Category 4a	Excess solar load from lack of shade
Lightning Creek – source to Rattle Creek	ID17010213PN019_03	Temperature	Yes	Category 4a	Excess solar load from lack of shade
Wellington Creek – source to mouth	ID17010213PN020_02	Temperature	Yes	Category 4a	Excess solar load from lack of shade

Solar load reductions to meet targets appear quite large when considering the total amount of kilowatt hours per day that would need to be removed from the AUs to meet target values. However, individual stream segments within 12 of the 22 AUs analyzed are on average relatively close to targeted stream shade values. This would indicate that stream segments and AUs are near potential natural vegetation shade values.

The PNV method not only identifies areas that are lacking shade, it is also used to identify areas that are over-widened compared to regional curves of stream widths based on basin size. The majority of streams in the subbasin are over-widened as based on observations made while conducting Solar Pathfinder measurements and when comparing measurements made during Beneficial Use Reconnaissance Program surveys. An increased bankfull width also increases the distance between streambank canopy and exposes the stream to increased solar loads.

Target shade levels for individual stream segments should be the goal managers strive for with future implementation plans. Managers should focus on the largest differences between existing and target shade as locations to prioritize implementation efforts.

This document was prepared with input from the public, as described in Appendix F. Following the public comment period, comments and DEQ responses will also be included in this appendix, and a distribution list will be included in **Error! Reference source not found.**.

References

Armantrout, N.B., compiler. 1998. *Glossary of Aquatic Habitat Inventory Terminology*. Bethesda, MD: American Fisheries Society.

Batt, P. E. (1996). *State of Idaho Bull Trout Conservation Plan.* Boise, ID: Office of the Governor.

CFR (Code of Federal Regulation). 1977. "Guidelines Establishing Test Procedures for the Analysis of Pollutants." 40 CFR 136.

CFR (Code of Federal Regulation). 1983. "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System." 40 CFR 122.

CFR (Code of Federal Regulation). 1983. "Water Quality Standards." 40 CFR 131.

CFR (Code of Federal Regulation). 1995. "Water Quality Planning and Management." 40 CFR 130.

DEQ (Idaho Department of Environmental Quality). 2005. *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*. Boise, ID: DEQ. Available at: *www.deq.idaho.gov/water-quality/wastewater/stormwater*.

DEQ. (2007). *Lower Clark Fork River Subbasin Assessment and Total Maximum Daily Loads.* Coeur d'Alene, ID: Idaho Department of Environmental Quality.

DEQ. (2013). *Upper (North Fork) Coeur d'Alene River Subbasin Temperature Total Maximum Daily Loads.* Coeur d'Alene, ID: Idaho Department of Environmental Quality.

DEQ (Idaho Department of Environmental Quality). 2016a. *Water Body Assessment Guidance.* 3rd ed. Boise, ID: Department of Environmental Quality.

DEQ (Idaho Department of Environmental Quality). 2016b. *Water Quality Pollutant Trading Guidance*. Boise, ID: DEQ. Available at: *www.deq.idaho.gov/water-quality/surface-water/pollutant-trading*.

DEQ. (2018). *Final 2016 Integrated Report.* Boise, ID: Idaho Department of Environmental Quality.

EPA (US Environmental Protection Agency) 1992. Guidelines for Reviewing TMDLs Under Existing Regulations Issued in 1992. Washington DC: EPA, Office of Water. Available at: https://www.epa.gov/sites/production/files/2015-10/documents/2002_06_04_tmdl_guidance_final52002.pdf

EPA (US Environmental Protection Agency). 1996. *Biological Criteria: Technical Guidance for Streams and Small Rivers*. Washington DC: EPA, Office of Water. EPA 822-B-96-001.

Frawley, S., Jakubowski R., and Bouwens, K.A. 2019. "2018 Idaho Tributary Salmonid Abundance Monitoring Annual Project Update." Idaho Tributary Habitat Acquisition and Enhancement Program, Appendix A

Idaho Code. 2017. "Creation of Watershed Advisory Groups." Idaho Code 39-3615.

Idaho Code. 2017. "Development and Implementation of Total Maximum Daily Load or Equivalent Processes." Idaho Code 39-3611.

IDAPA. 2017. "Idaho Water Quality Standards." Idaho Administrative Code. IDAPA 58.01.02.

IDFG. (2019). *Fisheries Management Plan 2019 – 2024.* Boise, USA: Idaho Department of Fish and Game.

IDL (Idaho Department of Lands). 2000. *Forest Practices Cumulative Watershed Effects Process for Idaho*. Boise, ID: IDL.

ISWCC (Idaho Soil and Water Conservation Commission). 2015. *Idaho Agricultural Pollution Abatement Plan*. Boise, ID: Resource Planning Unlimited, Inc.

Jakubowski R., and Bouwens, K.A. 2019. "2018 Pend Oreille Basin Bull Trout Redd Monitoring Project Update" Idaho Tributary Habitat Acquisition and Enhancement Program, Appendix A.

Küchler, A.U. 1964. "Potential Natural Vegetation of the Conterminous United States." American Geographical Society Special Publication 36.

McGrath, C.L., A.J. Woods, J.M. Omernik, S.A. Bryce, M. Edmondson, J.A. Nesser, J. Shelden, R.C. Crawford, J.A. Comstock, and M.D. Plocher. 2001. "Ecoregions of Idaho." Reston, VA: US Geological Survey.

Monitoring Trends in Burn Severity (MTBS) 2021. https://www.mtbs.gov/

OWEB (Oregon Watershed Enhancement Board). 2001. "Stream Shade and Canopy Cover Monitoring Methods." In *Water Quality Monitoring Technical Guide Book*, chap. 14. Salem, OR: OWEB.

Poole, G.C. and C.H. Berman. 2001. "An Ecological Perspective on In-Stream Temperature: Natural Heat Dynamics and Mechanisms of Human-Caused Thermal Degradation." *Environmental Management* 27(6):787–802.

Shumar, M.L. and J. De Varona. 2009. *The Potential Natural Vegetation (PNV) Temperature Total Maximum Daily Load (TMDL) Procedures Manual*. Boise, ID: Idaho Department of Environmental Quality.

Strahler, A.N. 1957. "Quantitative Analysis of Watershed Geomorphology." *Transactions American Geophysical Union* 38:913–920.

USFWS. 1999. *Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States.* Department of the Interior, US Fish and Wildlife Service; 64 FR 58910-58933.

USFWS. (2010). *Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States; Final Rule.* Department of the Interior, US Fish and Wildlife Service; 50 CFR 17, Vol. 75 No. 200.

USFWS (2015). Recovery Plan for the Coterminous United States Population of Bull Trout (*Slvelinus confluentus).* US Fish and Wildlife Service, Portland, Oregon

USFS. (2015). *Land Management Plan. 2015 Revision. Kootenai National Forest.* United States Forest Service - Northern Region.

USFS. (2017a). *East Fork Creek Fisheries Assessment. 2017.* US Forest Service – Sandpoint Ranger District Report.

USFS. (2017b). *Pend Oreille Tributaries Triennial Review. Forest Service – Sandpoint Ranger District Lightning Tributaries Report.* 2017. US Forest Service – Sandpoint Ranger District Report.

US Congress. 1972. Clean Water Act (Federal Water Pollution Control Act). 33 USC §1251–1387.

GIS Coverages

Restriction of liability: Neither the State of Idaho, nor the Department of Environmental Quality, nor any of their employees make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information or data provided. Metadata is provided for all data sets, and no data should be used without first reading and understanding its limitations. The data could include technical inaccuracies or typographical errors. The Department of Environmental Quality may update, modify, or revise the data used at any time, without notice.

IDWR (Idaho Department of Water Resources). 2018. Idaho Watershed Boundary Dataset (WBD). <*https://idwr.idaho.gov/gis/nhd/*> Finalized December 2, 2008. Boise, ID.

NAIP (National Agriculture Imagery Program). 2019. Digital ortho imagery, 60-centimeter resolution. Aerial Photography Field Office, Salt Lake City, UT. August 28, 2019.

US Bureau of Land Management. 2019. Surface Management Agency for Idaho. <http://insideidaho.org> Administrative land use boundaries updated twice yearly by the Engineering and Geographic Sciences department, Idaho State Office, U.S. Bureau of Land Management, Boise, ID.

U.S. Geological Survey, 2017, National Hydrography Dataset (Plus ver. 2 USGS National Hydrography Dataset 1:100k Resolution (NHD).

Glossary

§303(d)

Refers to section 303 subsection “d” of the Clean Water Act. Section 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to United States Environmental Protection Agency approval.

Assessment Unit (AU)

A group of similar streams that have similar land use practices, ownership, or land management. However, stream order is the main basis for determining AUs. All the waters of the state are defined using AUs, and because AUs are a subset of water body identification numbers, they tie directly to the water quality standards so that beneficial uses defined in the water quality standards are clearly tied to streams on the landscape.

Beneficial Use

Any of the various uses of water that are recognized in water quality standards, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics.

Beneficial Use Reconnaissance Program (BURP)

A program for conducting systematic biological and physical habitat surveys of water bodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers.

Exceedance

A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.

Fully Supporting

In compliance with water quality standards and within the range of biological reference conditions for all designated and existing beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Load Allocation (LA)

A portion of a water body’s load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).

Load

The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Load is the product of flow (discharge) and concentration.

Load Capacity (LC)

How much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, a margin of safety, and natural background contributions, it becomes a total maximum daily load.

Margin of Safety (MOS)

An implicit or explicit portion of a water body’s load capacity set aside to allow for uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. The margin of safety is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The margin of safety is not allocated to any sources of pollution.

Nonpoint Source

A dispersed source of pollutants generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and nonirrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Not Assessed (NA)

A concept and an assessment category describing water bodies that have been studied but are missing critical information needed to complete an assessment.

Not Fully Supporting

Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Point Source

A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater plants.

Pollutant

Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution

A very broad concept that encompasses human-caused changes in the environment that alter the functioning of natural processes and produce undesirable environmental and health effects. Pollution includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.

Potential Natural Vegetation (PNV)

A.U. Küchler (1964) defined potential natural vegetation as vegetation that would exist without human interference and if the resulting plant succession were projected to its climax condition while allowing for natural disturbance processes such as fire. Our use of the term reflects Küchler’s definition in that riparian vegetation at PNV would produce a system potential level of shade on streams and includes recognition of some level of natural disturbance.

Stream Order

Hierarchical ordering of streams based on the degree of branching. A 1st-order stream is an unforked or unbranched stream. Under Strahler’s (1957) system, higher-order streams result from the joining of two streams of the same order.

Total Maximum Daily Load (TMDL)

A TMDL is a water body’s load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual basis. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Wasteload Allocation (WLA)

The portion of receiving water's load capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

Water Body

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Quality Criteria

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, aquatic habitat, or industrial processes.

Water Quality Standards

State-adopted and United States Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Appendix A. Beneficial Uses

Idaho water quality standards (IDAPA 58.01.02) list beneficial uses and set water quality goals for waters of the state. Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses.

Existing Uses

Existing uses under the Clean Water Act are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards" (40 CFR 131.3). The existing instream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.051.01). Existing uses need to be protected, whether or not the level of water quality to fully support the uses currently exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water that supported salmonid spawning since November 28, 1975, but does not now due to other factors, such as blockage of migration, channelization, sedimentation, or excess heat.

Designated Uses

Designated uses under the Clean Water Act are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained" (40 CFR 131.3). Designated uses are simply uses officially recognized by the state. In Idaho, these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Multiple uses often apply to the same water; in this case, water quality must be sufficiently maintained to meet the most sensitive use (designated or existing). Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are described in the Idaho water quality standards (IDAPA 58.01.02.100) and specifically listed by water body in sections 110–160.

Undesignated Surface Waters and Presumed Use Protection

In Idaho, due to a change in scale of cataloging waters in 2000, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations (IDAPA 58.01.02.110–160). The water quality standards have three sections that address nondesignated waters. Sections 101.02 and 101.03 specifically address nondesignated man-made waterways and private waters. Man-made waterways and private waters have no presumed use protections. Man-made waters are protected for the use for which they were constructed unless otherwise designated in the water quality standards. Private waters are not protected for any beneficial uses unless specifically designated in the water quality standards.

All other undesignated waters are addressed by section 101.01. Under this section, absent information on existing uses, DEQ presumes that most Idaho waters will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called presumed uses, DEQ applies the numeric cold water and recreation criteria to undesignated waters. If in addition to presumed uses, an additional existing use (e.g., salmonid spawning) exists, then the additional numeric criteria for salmonid spawning would also apply (e.g., intergravel dissolved oxygen, temperature) because of the requirement to protect water quality for that existing use. However, if some other use that requires less stringent criteria for protection (such as seasonal cold aquatic life) is found to be an existing use, then a use designation (rulemaking) is needed before that use can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

Appendix B. State and Site-Specific Water Quality Standards and Criteria

Table B1. Selected numeric criteria supportive of designated beneficial uses in Idaho water quality standards.

Parameter	Primary Contact Recreation	Secondary Contact Recreation	Cold Water Aquatic Life	Salmonid Spawning[a]
Water Quality Standards: IDAPA 58.01.02.250–251				
Bacteria				
• Geometric mean	<126 *E. coli*/100 mL[b]	<126 *E. coli*/100 mL	—	—
• Single sample	≤406 *E. coli*/100 mL	≤576 *E. coli*/100 mL	—	—
pH	—	—	Between 6.5 and 9.0	Between 6.5 and 9.5
Dissolved oxygen (DO)	—	—	DO exceeds 6.0 milligrams/liter (mg/L)	**Water Column DO**: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater **Intergravel DO**: DO exceeds 5.0 mg/L for a 1-day minimum and exceeds 6.0 mg/L for a 7-day average
Temperature[c]	—	—	22 °C or less daily maximum; 19 °C or less daily average **Seasonal Cold Water**: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average	13 °C or less daily maximum; 9 °C or less daily average **Bull Trout**: Not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June–August; not to exceed 9 °C daily average in September and October
Turbidity	—	—	Turbidity shall not exceed background by more than 50 nephelometric turbidity units (NTU) instantaneously or more than 25 NTU for more than 10 consecutive days.	—
Ammonia	—	—	Ammonia not to exceed calculated concentration based on pH and temperature.	—
EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131				
Temperature	—	—	—	7-day moving average of 10 °C or less maximum daily temperature for June–September

[a] During spawning and incubation periods for inhabiting species
[b] *Escherichia coli* per 100 milliliters
[c] Temperature exemption: Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the 7-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning (SS) and egg incubation period, which varies by species. For spring-spawning salmonids, the default spawning and incubation period recognized by the Idaho Department of Environmental Quality (DEQ) is generally March 15 to July 15 (DEQ 2016a). Fall spawning can occur as early as September 1 and continue with incubation into the following spring up to June 1. As per IDAPA 58.01.02.250.02.f.ii., the following water quality criteria need to be met during that time period:

- 13 °C as a daily maximum water temperature
- 9 °C as a daily average water temperature

Additional criteria have been established for bull trout as per IDAPA 58.01.02.g. Within the rule bull trout criteria apply to key watersheds in the state where numeric standards are not to be exceeded during the bull trout rearing and spawning periods. The bull trout rearing period is from June—August and spawning occurs in September and October. The temperature standards in those periods are:

- 13 °C as a maximum weekly maximum temperature in the juvenile bull trout rearing period
- 9 °C as a daily average in the spawning period

The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

The maximum weekly maximum temperature is defined as the mean of the daily maximum water temperatures measured over the annual warmest consecutive seven day period during any given year.

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of the highest annual maximum weekly maximum air temperatures) is compared to the daily maximum criterion of 13 °C.

The DEQ Coeur d'Alene Regional Office set the general spawning and incubation windows with assistance from the IDFG to better reflect and protect SS and incubation in northern Idaho (Table B2).

Table B2. Time periods for applying Idaho SS temperature criteria in the Idaho Panhandle.

Species	Timing
Westslope Cutthroat Trout	Elevation ≥ 4000 feet (1,219 meters) = June 1–July 31 Elevation 3,000–4,000 feet (914–1,219 meters) = May 15–July 15 Elevation < 3,000 feet (< 914 meters) = May 1–July 1
Rainbow Trout	May 1–July 1
Fall spawning salmonids	August 15–November 15
Bull Trout	September 1–October 31

The COLD criteria are not discussed in this section because where COLD beneficial use criteria apply, the SS criteria also apply and are more protective (i.e., require a lower temperature) than the COLD criteria. When temperature data exceed the more protective SS criteria, the water body is identified as impaired by temperature regardless of whether it fails the COLD criteria.

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.050.02. The procedure relies heavily upon biological parameters and is presented in detail in DEQ (2016). This guidance requires DEQ to use the most complete data available to make beneficial use support status determinations.

DEQ allows for minor exceedances of water quality temperature criteria when the exceedance occurs less than 10% of the critical time period and no other evidence of thermal inputs exists (DEQ 2016). Exceptions are also made for water temperature exceedances that occur during periods when air temperatures exceed the 90th percentile of air temperatures recorded in the area (DEQ 2016).

Natural Background Provisions

For potential natural vegetation temperature TMDLs, it is assumed that natural temperatures may exceed these criteria during certain time periods. If potential natural vegetation targets are achieved yet stream temperatures are warmer than these criteria, it is assumed that the stream's temperature is natural (provided there are no point sources or human-induced ground water sources of heat) and natural background provisions of Idaho water quality standards apply:

> When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, there shall be no lowering of water quality from natural background conditions. Provided, however, that temperature may be increased above natural background conditions when allowed under Section 401. (IDAPA 58.01.02.200.09)

Section 401 relates to point source wastewater treatment requirements. In this case, if temperature criteria for any aquatic life use are exceeded due to natural conditions, then a point source discharge cannot raise the water temperature by more than 0.3 °C (IDAPA 58.01.02.401.01.c).

Appendix C. Data Sources

Table C1. Data sources for Lower Clark Fork River subbasin assessment.

Data Source	Data Type	Collection Date
DEQ Coeur d'Alene Regional Office	Solar Pathfinder effective shade and stream width estimates	June 2018
DEQ Technical Services Division	Lower Clark Fork River subbasin shade curves	January 2020
DEQ Technical Services Division	Lower Clark Fork River subbasin solar load tables	March 2020
DEQ Technical Services Division	Lower Clark Fork River subbasin existing, target, and shade deficit figures	March 2020

Bankfull Width Estimates

Table C2. Natural bankfull width estimates in Lower Clark Fork River subbasin.

Johnson Creek – source to mouth ID17010213PN002_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Johnson Creek_Trib 01	0.5	2	
Johnson Creek @ Trib 02	3.1	4	
Johnson Creek_Trib 02	1.8	3	
Johnson Creek @ Trib 03	5.6	5	
Johnson Creek_Trib 03	1.0	3	
Johnson Creek @ Trib 04	7.4	6	
Johnson Creek_Trib 04	0.8	2	
Johnson Creek @ West Johnson Creek	8.3	6	
West Johnson Creek_Trib 01	1.2	3	
West Johnson Creek @ Trib 01	0.6	2	
West Johnson Creek_Trib 02	0.6	2	
West Johnson Creek @ Trib 02	1.9	3	3
West Johnson Creek_Trib 03	0.6	2	
West Johnson Creek	3.4	4	

Johnson Creek – source to mouth ID17010213PN002_03			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Johnson Creek	13.9	7	

Twin Creek – 1st & 2nd order Twin & Delyle Creek ID17010213PN004_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Twin Creek @ Trib 01	1.7	3	
Twin Creek @ Delyle Creek	3.8	4	5
Delyle Creek	2.2	3	
North Fork Twin Creek	2.7	4	
Twin Creek_Trib 02	0.7	2	
Ruen Creek	0.8	2	

Dry Creek ID17010213PN004_02a			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Dry Creek @ Trib 01	5.4	5	
Dry Creek	12.9	7	

Twin Creek – Delyle Creek to Clark Fork River ID17010213PN004_03			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Twin Creek	24.8	9	5

Mosquito Creek – source to mouth ID17010213PN009_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Mosquito Creek_Trib 01	1.5	3	
Mosquito Creek @ Trib 01	1.6	3	
Mosquito Creek near Clark Fork Field School	5.2	5	5
Mosquito Creek @ mouth	8.5	6	

Lightning Creek – Spring Creek to mouth ID17010213PN010_04			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Lightning Creek @ mouth	117.8	17	

Lightning Creek – Cascade Creek to Spring Creek ID17010213PN011_04			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Lightning Creek @ Spring Creek	106.9	17	

Cascade Creek – source to mouth ID17010213PN012_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Webb Canyon	1.8	3	
Cascade Creek @ Lightning Creek	5.7	5	

Lightning Creek – East Fork Creek to Cascade Creek ID17010213PN013_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Lightning Creek_Trib 02	0.5	2	
Lightning Creek_Trib 03	0.7	2	
Morris Creek	4.8	5	6
Lightning Creek_Trib 04	0.6	2	
Regal Creek	1.1	3	
Lightning Creek_Trib 05	0.5	2	

Lightning Creek – East Fork Creek to Cascade Creek ID17010213PN013_04			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Lightning Creek @ Regal Creek	93.8	16	20
Lightning Creek @ Cascade Creek	100.3	16	

East Fork Creek – Idaho/Montana border to mouth ID17010213PN014_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Char Creek	3.5	4	
East Fork @ Idaho border	6.9	6	
East Fork Creek @ Char Creek	7.9	6	
East Fork Creek @ Savage Creek	13.4	7	6

East Fork Creek – Idaho/Montana border to mouth ID17010213PN014_03			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
East Fork Creek near Savage Creek	20.1	8	10
East Fork Creek @ Lightning Creek	20.5	9	

Savage Creek – Idaho/Montana border to mouth ID17010213PN015_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Savage Creek	6.6	5	7

Tribs. To Lightning Cr between Wellington & E. Fork Creek ID17010213PN016_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Mud Creek	1.3	3	
Steep Creek	0.7	2	
Jost Creek	0.7	2	
Lightning Creek_Trib 01	0.8	2	
Silvertip Creek	1.1	3	
Porcupine Creek	7.4	6	12
Trapper Creek	1.1	3	

Lightning Creek – Wellington Creek to East Fork Creek ID17010213PN016_03			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Lightning Creek near Silvertip Creek	52.4	12	30

Lightning Creek – tribs between Wellington & Rattle Creek ID17010213PN017_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Sheep Creek	1.0	3	
Bear Creek	0.9	2	

Lightning Creek – Rattle Creek to Wellington Creek ID17010213PN017_03			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Lightning Creek @ Wellington Creek	36.9	11	

Rattle Creek – source to mouth ID17010213PN018_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Rattle Creek	10.5	7	

Lightning Creek – source to Rattle Creek ID17010213PN019_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Gem Creek	0.7	2	
Gordon Creek	1.2	3	
Moose Creek	4.2	5	
Lunch Creek	0.8	2	
Lightning Creek @ Lunch Creek	11.5	7	11
Quartz Creek	3.8	4	5
Deer Creek	1.9	3	4
Fall Creek	1.1	3	
Lightning Creek @ Quartz Creek	12.5	7	

Lightning Creek – source to Rattle Creek ID17010213PN019_03			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
Lightning Creek @ Rattle Creek	21.2	9	

Wellington Creek – source to mouth ID17010213PN020_02			
Location	Area (sq mi)	Pend Oreille (m)	BURP (m)
South Fork Wellington Creek	3.5	4	
Wellington Creek @ SF Wellington Creek	2.2	4	
Wellington Creek_Trib 01	1.77	3	
Wellington Creek @ Lightning Creek	9.73	6	7

Selected Shade Curves

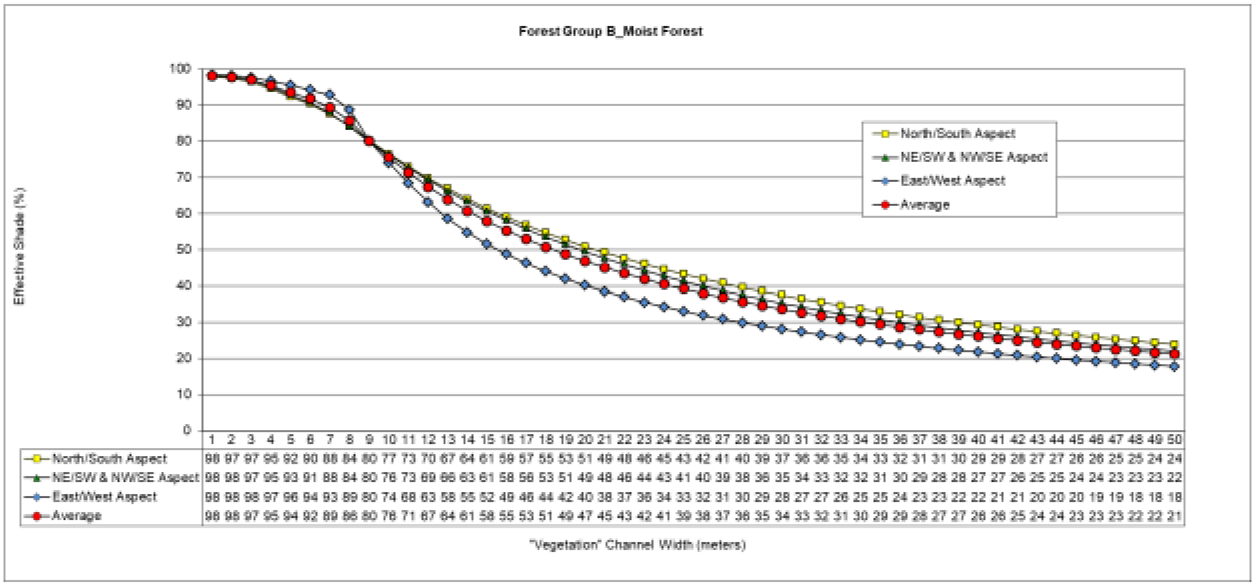

Figure C1. Lower Clark Fork River subbasin Kaniksu – Group B forest type shade curve

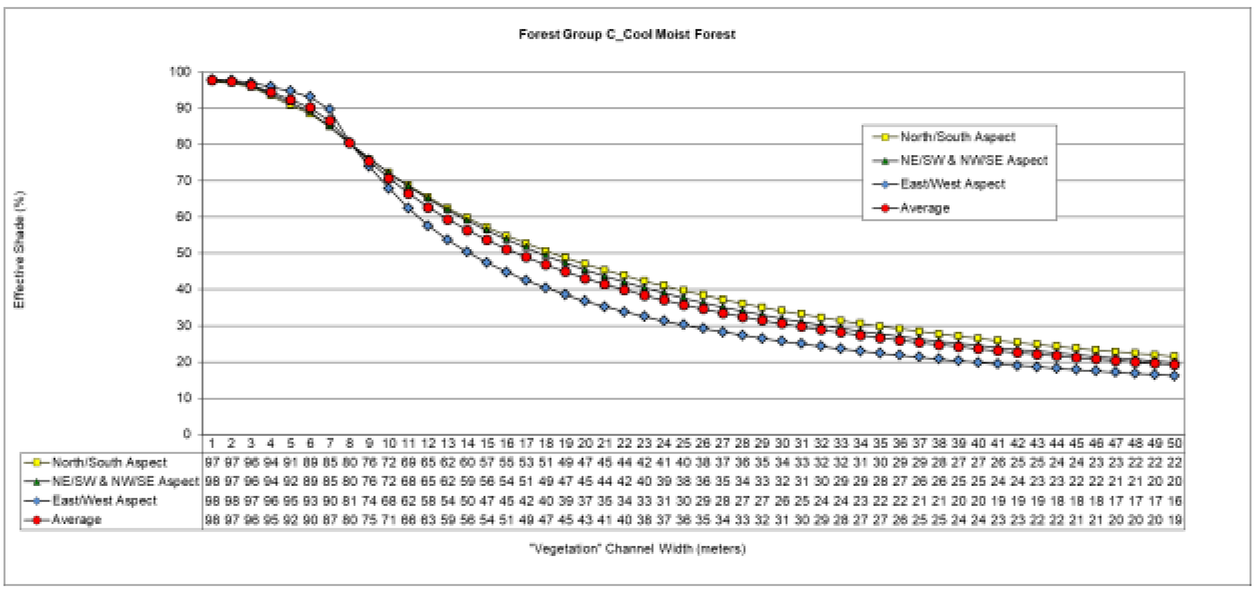

Figure C2. Lower Clark Fork River subbasin Kaniksu – Group C forest type shade curve

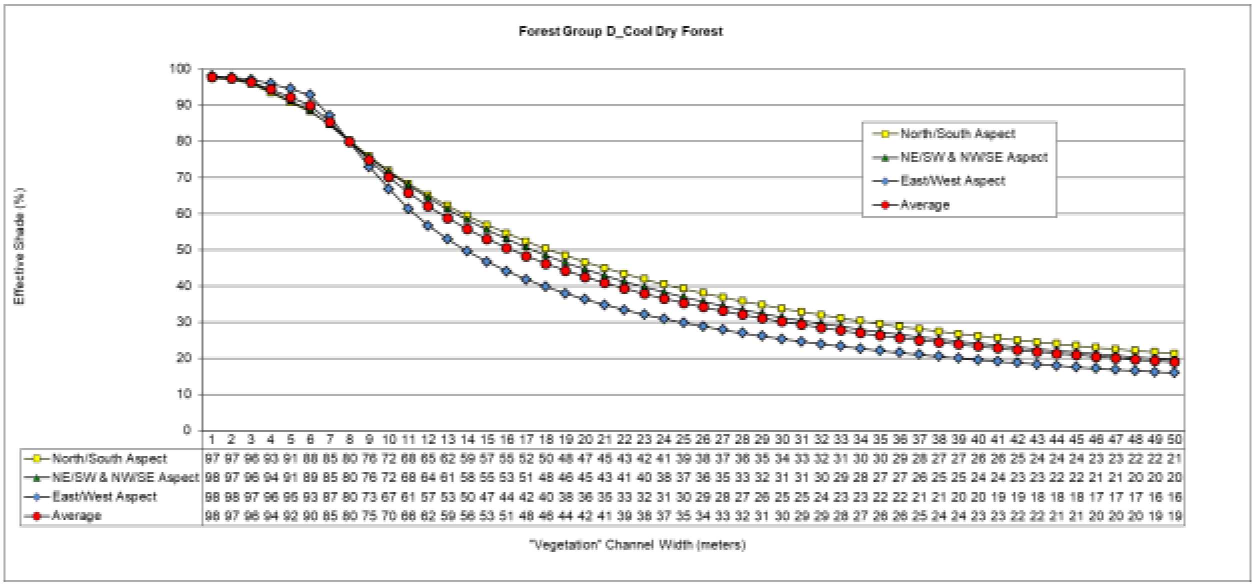

Figure C3. Lower Clark Fork River subbasin Kaniksu – Group D forest type shade curve

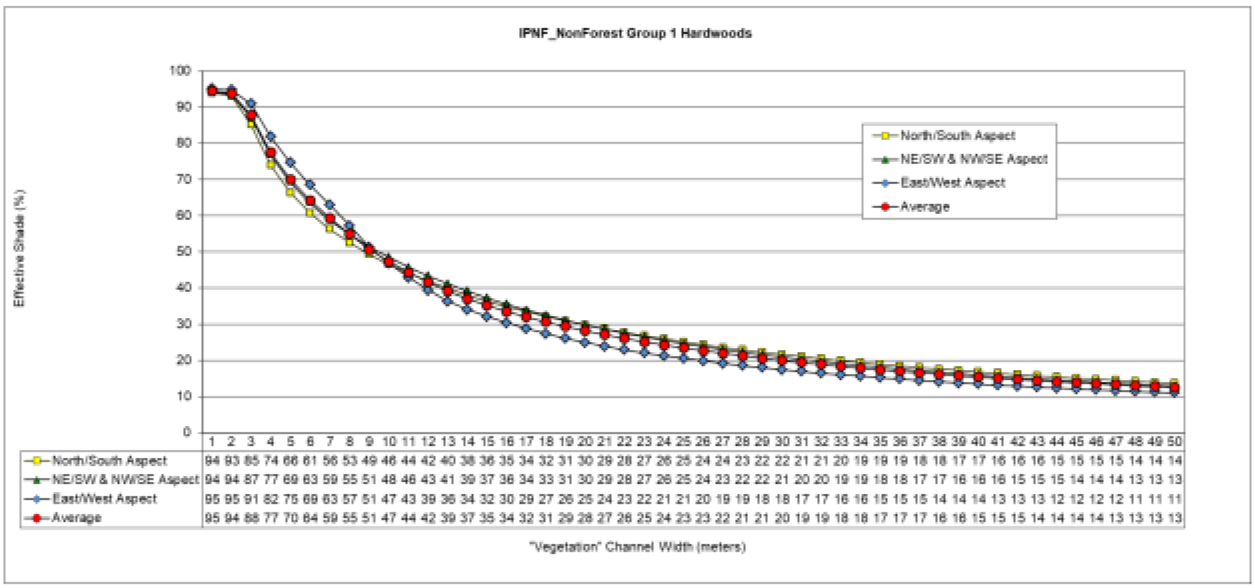

Figure C4. Lower Clark Fork River subbasin Idaho Panhandle National Forest non-forest hardwood group shade curve

Solar Load Tables

Table C3. Target and existing solar loads for Johnson Creek – source to mouth (ID17010213PN002_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
002_02	Johnson Creek	1	942	Forest Group B	98%	0.11	1	900	100	90%	0.57	1	900	500	400	-8%
002_02	Johnson Creek	2	932	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	3	3,000	3,000	3,000	-18%
002_02	Johnson Creek	3	240	Forest Group B	98%	0.11	2	500	60	80%	1.14	3	700	800	700	-18%
002_02	Johnson Creek	4	582	Forest Group B	98%	0.11	2	1,000	100	80%	1.14	3	2,000	2,000	2,000	-18%
002_02	Johnson Creek	5	462	Forest Group B	98%	0.11	2	900	100	80%	1.14	3	1,000	1,000	900	-18%
002_02	Johnson Creek	6	592	Forest Group B	96%	0.23	4	2,000	500	80%	1.14	5	3,000	3,000	3,000	-16%
002_02	Johnson Creek	7	759	Forest Group B	96%	0.23	4	3,000	700	80%	1.14	5	4,000	5,000	4,000	-16%
002_02	Johnson Creek	8	204	Forest Group B	94%	0.34	5	1,000	300	80%	1.14	6	1,000	1,000	700	-14%
002_02	Johnson Creek	9	1006	Forest Group B	94%	0.34	5	5,000	2,000	90%	0.57	6	6,000	3,000	1,000	-4%
002_02	Johnson Creek	10	398	Forest Group B	94%	0.34	5	2,000	700	90%	0.57	6	2,000	1,000	300	-4%
002_02	Johnson Creek	11	199	Forest Group B	94%	0.34	5	1,000	300	80%	1.14	6	1,000	1,000	700	-14%
002_02	Johnson Creek_Trib 01	1	1208	Forest Group B	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
002_02	Johnson Creek_Trib 01	2	411	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
002_02	Johnson Creek_Trib 01	3	69	Forest Group B	98%	0.11	1	70	8	90%	0.57	1	70	40	30	-8%
002_02	Johnson Creek_Trib 02	1	231	Forest Group B	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
002_02	Johnson Creek_Trib 02	2	173	Forest Group B	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
002_02	Johnson Creek_Trib 02	3	986	Forest Group B	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
002_02	Johnson Creek_Trib 02	4	156	Forest Group B	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
002_02	Johnson Creek_Trib 02	5	147	Forest Group B	98%	0.11	2	300	30	90%	0.57	3	400	200	200	-8%
002_02	Johnson Creek_Trib 02	6	229	Forest Group B	98%	0.11	2	500	60	90%	0.57	3	700	400	300	-8%

002_02	Johnson Creek_Trib 02	7	817	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	3	2,000	2,000	2,000	-18%
002_02	Johnson Creek_Trib 02a	1	422	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
002_02	Johnson Creek_Trib 02a	2	227	Forest Group B	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
002_02	Johnson Creek_Trib 02a	3	787	Forest Group B	98%	0.11	1	800	90	80%	1.14	1	800	900	800	-18%
002_02	Johnson Creek_Trib 02a	4	126	Forest Group B	98%	0.11	1	100	10	90%	0.57	1	100	60	50	-8%
002_02	Johnson Creek_Trib 03	1	505	Forest Group B	98%	0.11	1	500	60	90%	0.57	1	500	300	200	-8%
002_02	Johnson Creek_Trib 03	2	779	Forest Group B	98%	0.11	1	800	90	80%	1.14	1	800	900	800	-18%
002_02	Johnson Creek_Trib 03	3	779	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	3	2,000	2,000	2,000	-18%
002_02	Johnson Creek_Trib 04	1	1053	Forest Group B	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
002_02	Johnson Creek_Trib 04	2	151	Forest Group B	98%	0.11	2	300	30	70%	1.71	3	500	900	900	-28%
002_02	Johnson Creek_Trib 04	3	246	Forest Group B	98%	0.11	2	500	60	80%	1.14	3	700	800	700	-18%
002_02	Johnson Creek_Trib 04	4	119	Forest Group B	98%	0.11	2	200	20	70%	1.71	3	400	700	700	-28%
002_02	Johnson Creek_Trib 04	5	405	Forest Group B	98%	0.11	2	800	90	80%	1.14	3	1,000	1,000	900	-18%
002_02	West Fork Johnson Creek	1	291	Forest Group B	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
002_02	West Fork Johnson Creek	2	1975	Forest Group B	98%	0.11	1	2,000	200	80%	1.14	1	2,000	2,000	2,000	-18%
002_02	West Fork Johnson Creek	3	302	Forest Group B	98%	0.11	2	600	70	80%	1.14	3	900	1,000	900	-18%
002_02	West Fork Johnson Creek	4	71	Forest Group B	97%	0.17	3	200	30	50%	2.85	4	300	900	900	-47%
002_02	West Fork Johnson Creek	5	372	Forest Group B	97%	0.17	3	1,000	200	80%	1.14	4	1,000	1,000	800	-17%
002_02	West Fork Johnson Creek	6	30	Forest Group B	97%	0.17	3	90	20	50%	2.85	4	100	300	300	-47%
002_02	West Fork Johnson Creek	7	389	Forest Group B	97%	0.17	3	1,000	200	50%	2.85	4	2,000	6,000	6,000	-47%
002_02	West Fork Johnson Creek	8	169	Forest Group B	97%	0.17	3	500	90	50%	2.85	4	700	2,000	2,000	-47%
002_02	West Fork Johnson Creek	9	457	Forest Group B	97%	0.17	3	1,000	200	80%	1.14	4	2,000	2,000	2,000	-17%
002_02	West Johnson Creek_Trib 01	1	476	Forest Group B	98%	0.11	1	500	60	70%	1.71	1	500	900	800	-28%
002_02	West Johnson Creek_Trib 01	2	569	Forest Group B	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
002_02	West Johnson Creek_Trib 01	3	142	Forest Group B	98%	0.11	1	100	10	70%	1.71	1	100	200	200	-28%
002_02	West Johnson Creek_Trib 01	4	56	Forest Group B	98%	0.11	1	60	7	50%	2.85	1	60	200	200	-48%
002_02	West Johnson Creek_Trib 01	5	986	Forest Group B	98%	0.11	2	2,000	200	50%	2.85	3	3,000	9,000	9,000	-48%

002_02	West Johnson Creek_Trib 01	6	242	Forest Group B	98%	0.11	2	500	60	80%	1.14	3	700	800	700	-18%
002_02	West Johnson Creek_Trib 01a	1	222	Forest Group B	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
002_02	West Johnson Creek_Trib 01a	2	292	Forest Group B	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
002_02	West Johnson Creek_Trib 01a	3	242	Forest Group B	98%	0.11	1	200	20	50%	2.85	1	200	600	600	-48%
002_02	West Johnson Creek_Trib 01a	4	115	Forest Group B	98%	0.11	1	100	10	70%	1.71	1	100	200	200	-28%
002_02	West Johnson Creek_Trib 01a	5	163	Forest Group B	98%	0.11	1	200	20	50%	2.85	1	200	600	600	-48%
002_02	West Johnson Creek_Trib 02	1	337	Forest Group B	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
002_02	West Johnson Creek_Trib 02	2	626	Forest Group B	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
002_02	West Johnson Creek_Trib 02	3	943	Forest Group B	98%	0.11	1	900	100	70%	1.71	1	900	2,000	2,000	-28%
002_02	West Johnson Creek_Trib 02	4	54	Forest Group B	98%	0.11	2	100	10	30%	3.99	3	200	800	800	-68%
002_02	West Johnson Creek_Trib 03	1	1394	Forest Group B	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
002_02	West Johnson Creek_Trib 03	2	305	Forest Group B	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
002_02	West Johnson Creek_Trib 03	3	224	Forest Group B	98%	0.11	2	400	50	90%	0.57	3	700	400	400	-8%
							Totals		8,400					71,000	65,000	

Table C4. Target and existing solar loads for Johnson Creek – source to mouth (ID17010213PN002_03)

Segment Details					Target					Existing					Summary	
AU	**Stream Name**	**Number (top to bottom)**	**Length (m)**	**Vegetation Type**	**Shade**	**Solar Radiation (kWh/m²/day)**	**Segment Width (m)**	**Segment Area (m²)**	**Solar Load (kWh/day)**	**Shade**	**Solar Radiation (kWh/m²/day)**	**Segment Width (m)**	**Segment Area (m²)**	**Solar Load (kWh/day)**	**Excess Load (kWh/day)**	**Lack of Shade**
002_03	Johnson Creek	12	721	Forest Group B	92%	0.46	6	4,000	2,000	80%	1.14	7	5,000	6,000	4,000	-12%
002_03	Johnson Creek	13	367	Forest Group B	92%	0.46	6	2,000	900	70%	1.71	7	3,000	5,000	4,000	-22%
002_03	Johnson Creek	14	1125	Forest Group B	92%	0.46	6	6,800	3,100	80%	1.14	7	7,900	9,000	5,900	-12%
002_03	Johnson Creek	15	446	Forest Group B	92%	0.46	6	2,700	1,200	80%	1.14	7	3,100	3,500	2,300	-12%
002_03	Johnson Creek	16	274	Forest Group B	92%	0.46	6	1,600	730	60%	2.28	7	1,900	4,300	3,600	-32%
							Totals		7,900					28,000	20,000	

Table C5. Target and existing solar loads for Twin Creek – 1st & 2nd order Twin & Delyle Creek (ID17010213PN004_02)

Segment Details	Target	Existing	Summary

AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
004_02	Delyle Creek	1	962	Forest Group B	98%	0.11	1	1,000	100	80%	1.14	1	1,000	1,000	900	-18%
004_02	Delyle Creek	2	1216	Forest Group B	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
004_02	Delyle Creek	3	1951	Forest Group B	98%	0.11	1	2,000	200	80%	1.14	1	2,000	2,000	2,000	-18%
004_02	Delyle Creek	4	820	Forest Group B	98%	0.11	2	2,000	200	70%	1.71	3	2,000	3,000	3,000	-28%
004_02	North Fork Twin Creek	1	861	Forest Group B	98%	0.11	1	900	100	90%	0.57	1	900	500	400	-8%
004_02	North Fork Twin Creek	2	460	Forest Group B	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
004_02	North Fork Twin Creek	3	1835	Forest Group B	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
004_02	North Fork Twin Creek	4	788	Forest Group B	98%	0.11	2	2,000	200	90%	0.57	3	2,000	1,000	800	-8%
004_02	North Fork Twin Creek	5	503	Forest Group B	98%	0.11	2	1,000	100	70%	1.71	3	2,000	3,000	3,000	-28%
004_02	North Fork Twin Creek_Trib 01	1	684	Forest Group B	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
004_02	North Fork Twin Creek_Trib 01	2	302	Forest Group B	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
004_02	North Fork Twin Creek_Trib 01	3	593	Forest Group B	98%	0.11	1	600	70	90%	0.57	1	600	300	200	-8%
004_02	North Fork Twin Creek_Trib 01	4	402	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
004_02	Ruen Creek	1	1087	Forest Group B	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
004_02	Ruen Creek	2	1087	Forest Group B	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
004_02	Twin Creek	1	475	Forest Group B	98%	0.11	1	500	60	50%	2.85	1	500	1,000	900	-48%
004_02	Twin Creek	2	503	Forest Group B	98%	0.11	1	500	60	70%	1.71	1	500	900	800	-28%
004_02	Twin Creek	3	479	Forest Group B	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
004_02	Twin Creek	4	1791	Forest Group B	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
004_02	Twin Creek	5	1310	Forest Group B	98%	0.11	2	3,000	300	90%	0.57	3	4,000	2,000	2,000	-8%
004_02	Twin Creek	6	737	Forest Group B	98%	0.11	2	1,000	100	70%	1.71	3	2,000	3,000	3,000	-28%
004_02	Twin Creek_Trib 01	1	1601	Forest Group B	98%	0.11	1	2,000	200	90%	0.57	1	2,000	1,000	800	-8%
004_02	Twin Creek_Trib 02	1	201	Forest Group B	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
004_02	Twin Creek_Trib 02	2	432	Forest Group B	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%

004_02	Twin Creek_Trib 02	3	337	Forest Group B	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
004_02	Twin Creek_Trib 02	4	279	Forest Group B	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
004_02	Twin Creek_Trib 02	5	238	Forest Group B	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
004_02	Twin Creek_Trib 02	6	413	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
							Totals		2,900					27,000	25,000	

Table C6. Target and existing solar loads for Dry Creek (ID17010213PN004_02a)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
004_02a	Dry Creek	1	743	Forest Group B	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
004_02a	Dry Creek	2	4039	Forest Group B	98%	0.11	2	8,000	900	90%	0.57	3	10,000	6,000	5,000	-8%
004_02a	Dry Creek	3	996	Forest Group B	98%	0.11	2	2,000	200	70%	1.71	3	3,000	5,000	5,000	-28%
004_02a	Dry Creek	4	697	Forest Group B	98%	0.11	2	1,000	100	80%	1.14	3	2,000	2,000	2,000	-18%
004_02a	Dry Creek	5	2091	Forest Group B	97%	0.17	3	6,000	1,000	90%	0.57	4	8,000	5,000	4,000	-7%
004_02a	Dry Creek	6	672	Forest Group B	97%	0.17	3	2,000	300	70%	1.71	4	3,000	5,000	5,000	-27%
004_02a	Dry Creek	7	663	Forest Group B	97%	0.17	3	2,000	300	80%	1.14	4	3,000	3,000	3,000	-17%
004_02a	Dry Creek	8	1714	Forest Group B	97%	0.17	3	5,000	900	70%	1.71	4	7,000	10,000	9,000	-27%
004_02a	Dry Creek_Trib 01	1	696	Forest Group B	98%	0.11	1	700	80	90%	0.57	1	700	400	300	-8%
004_02a	Dry Creek_Trib 01	2	197	Forest Group B	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
004_02a	Dry Creek_Trib 01	3	214	Forest Group B	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
004_02a	Dry Creek_Trib 01	4	409	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
004_02a	Dry Creek_Trib 01	5	114	Forest Group B	98%	0.11	1	100	10	80%	1.14	1	100	100	90	-18%
004_02a	Dry Creek_Trib 01	6	190	Forest Group B	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
004_02a	Dry Creek_Trib 01	7	2105	Forest Group B	98%	0.11	2	4,000	500	90%	0.57	3	6,000	3,000	3,000	-8%
							Totals		4,500					41,000	38,000	

Table C7. Target and existing solar loads for Twin Creek – Delyle Creek to Clark Fork River (ID17010213PN004_03)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
004_03	Twin Creek	7	124	Forest Group B	98%	0.11	2	200	20	70%	1.71	3	400	700	700	-28%
004_03	Twin Creek	8	313	Forest Group B	97%	0.17	3	900	200	80%	1.14	4	1,000	1,000	800	-17%
004_03	Twin Creek	9	1224	Forest Group B	97%	0.17	3	4,000	700	70%	1.71	4	5,000	9,000	8,000	-27%
004_03	Twin Creek	10	162	Forest Group B	97%	0.17	3	500	90	80%	1.14	4	600	700	600	-17%
004_03	Twin Creek	11	354	Forest Group B	97%	0.17	3	1,000	200	70%	1.71	4	1,000	2,000	2,000	-27%
004_03	Twin Creek	12	1022	Forest Group B	97%	0.17	3	3,000	500	80%	1.14	4	4,000	5,000	5,000	-17%
004_03	Twin Creek	13	2361	Forest Group B	94%	0.34	5	12,000	4,100	20%	4.56	6	14,000	64,000	60,000	-74%
							Totals		5,800					82,000	77,000	

Table C8. Target and existing solar loads for Mosquito Creek – source to mouth (ID17010213PN009_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
009_02	Mosquito Creek	1	232	Forest Group C	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
009_02	Mosquito Creek	2	194	Forest Group B	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
009_02	Mosquito Creek	3	3193	Forest Group B	98%	0.11	2	6,000	700	90%	0.57	3	10,000	6,000	5,000	-8%
009_02	Mosquito Creek	4	570	Forest Group B	98%	0.11	2	1,000	100	80%	1.14	3	2,000	2,000	2,000	-18%
009_02	Mosquito Creek	5	796	Forest Group B	97%	0.17	3	2,000	300	90%	0.57	4	3,000	2,000	2,000	-7%
009_02	Mosquito Creek	6	789	Forest Group B	96%	0.23	4	3,000	700	80%	1.14	5	4,000	5,000	4,000	-16%
009_02	Mosquito Creek	7	1132	Forest Group B	96%	0.23	4	5,000	1,000	90%	0.57	5	6,000	3,000	2,000	-6%
009_02	Mosquito Creek	8	195	Forest Group B	94%	0.34	5	1,000	300	80%	1.14	6	1,000	1,000	700	-14%
009_02	Mosquito Creek	9	794	Forest Group B	94%	0.34	5	4,000	1,000	90%	0.57	6	5,000	3,000	2,000	-4%
009_02	Mosquito Creek	10	249	Forest Group B	94%	0.34	5	1,000	300	70%	1.71	6	1,000	2,000	2,000	-24%
009_02	Mosquito Creek	11	239	Forest Group B	94%	0.34	5	1,000	300	20%	4.56	6	1,000	5,000	5,000	-74%
009_02	Mosquito Creek	12	230	Forest Group B	92%	0.46	6	1,000	500	50%	2.85	7	2,000	6,000	6,000	-42%
009_02	Mosquito Creek	13	1078	Forest Group B	92%	0.46	6	6,000	3,000	10%	5.13	7	8,000	40,000	40,000	-82%
009_02	Mosquito Creek_Trib 01	1	1032	Forest Group B	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
009_02	Mosquito Creek_Trib 01	2	231	Forest Group B	98%	0.11	1	200	20	20%	4.56	1	200	900	900	-78%
009_02	Mosquito Creek_Trib 01	3	348	Forest Group B	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%

009_02	Mosquito Creek_Trib 01	4	1154	Forest Group B	98%	0.11	2	2,000	200	90%	0.57	3	3,000	2,000	2,000	-8%
009_02	Mosquito Creek_Trib 01	5	197	Forest Group B	98%	0.11	2	400	50	80%	1.14	3	600	700	700	-18%
009_02	Mosquito Creek_Trib 01	6	1326	Forest Group B	98%	0.11	2	3,000	300	90%	0.57	3	4,000	2,000	2,000	-8%
							Totals		8,900					82,000	78,000	

Table C9. Target and existing solar loads for Lightning Creek – Spring Creek to mouth (ID17010213PN010_04)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
010_04	Lightning Creek	28	2206	Non-Forest Group 1	23%	4.39	24	53,000	230,000	20%	4.56	25	55,000	250,000	20,000	-3%
							Totals		230,000					250,000	20,000	

Table C10. Target and existing solar loads for Lightning Creek – Cascade Creek to Spring Creek (ID17010213PN011_04)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
011_04	Lightning Creek	26	2890	Non-Forest Group 1	24%	4.33	24	69,000	300,000	0%	5.70	25	72,000	410,000	110,000	-24%
011_04	Lightning Creek	27	1403	Non-Forest Group 1	24%	4.33	24	34,000	150,000	0%	5.70	25	35,000	200,000	50,000	-24%
							Totals		450,000					610,000	160,000	

Table C11. Target and existing solar loads for Lightning Creek – East Fork Creek to Cascade Creek (ID17010213PN013_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m^2/day)	Segment Width (m)	Segment Area (m^2)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
013_02	Lightning Creek_Trib 02	1	954	Forest Group C	98%	0.11	1	1,000	100	70%	1.71	1	1,000	2,000	2,000	-28%
013_02	Lightning Creek_Trib 02	2	468	Forest Group C	97%	0.17	2	900	200	60%	2.28	3	1,000	2,000	2,000	-37%
013_02	Lightning Creek_Trib 02	3	440	Forest Group C	97%	0.17	2	900	200	70%	1.71	3	1,000	2,000	2,000	-27%

013_02	Lightning Creek_Trib 03	1	881	Forest Group B	98%	0.11	1	900	100	70%	1.71	1	900	2,000	2,000	-28%
013_02	Lightning Creek_Trib 03	2	1294	Forest Group B	98%	0.11	2	3,000	300	70%	1.71	3	4,000	7,000	7,000	-28%
013_02	Lightning Creek_Trib 04	1	1423	Forest Group C	98%	0.11	1	1,000	100	70%	1.71	1	1,000	2,000	2,000	-28%
013_02	Lightning Creek_Trib 04	2	427	Forest Group C	97%	0.17	2	900	200	50%	2.85	3	1,000	3,000	3,000	-47%
013_02	Lightning Creek_Trib 05	1	376	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
013_02	Lightning Creek_Trib 05	2	335	Forest Group B	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
013_02	Lightning Creek_Trib 05	3	487	Forest Group B	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
013_02	Lightning Creek_Trib 05	4	634	Forest Group B	98%	0.11	2	1,000	100	90%	0.57	3	2,000	1,000	900	-8%
013_02	Morris Creek	1	829	Forest Group C	98%	0.11	1	800	90	90%	0.57	1	800	500	400	-8%
013_02	Morris Creek	2	924	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	3	3,000	3,000	3,000	-18%
013_02	Morris Creek	3	282	Forest Group B	97%	0.17	3	800	100	90%	0.57	4	1,000	600	500	-7%
013_02	Morris Creek	4	164	Forest Group B	97%	0.17	3	500	90	80%	1.14	4	700	800	700	-17%
013_02	Morris Creek	5	190	Forest Group B	97%	0.17	3	600	100	90%	0.57	4	800	500	400	-7%
013_02	Morris Creek	6	204	Forest Group B	97%	0.17	3	600	100	80%	1.14	4	800	900	800	-17%
013_02	Morris Creek	7	219	Forest Group B	97%	0.17	3	700	100	90%	0.57	4	900	500	400	-7%
013_02	Morris Creek	8	1483	Forest Group B	95%	0.29	4	6,000	2,000	80%	1.14	5	7,000	8,000	6,000	-15%
013_02	Morris Creek	9	803	Forest Group B	94%	0.34	5	4,000	1,000	80%	1.14	6	5,000	6,000	5,000	-14%
013_02	Morris Creek_Trib 01	1	206	Forest Group B	98%	0.11	1	200	20	60%	2.28	1	200	500	500	-38%
013_02	Morris Creek_Trib 01	2	1075	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	2	2,000	2,000	2,000	-18%
013_02	Regal Creek	1	747	Forest Group B	98%	0.11	1	700	80	60%	2.28	1	700	2,000	2,000	-38%
013_02	Regal Creek	2	776	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	3	2,000	2,000	2,000	-18%
013_02	Regal Creek	3	345	Forest Group C	97%	0.17	2	700	100	80%	1.14	3	1,000	1,000	900	-17%
013_02	Regal Creek	4	223	Forest Group C	96%	0.23	3	700	200	90%	0.57	4	900	500	300	-6%
013_02	Regal Creek	5	679	Forest Group B	97%	0.17	3	2,000	300	90%	0.57	4	3,000	2,000	2,000	-7%
							Totals		6,300					53,000	49,000	

Table C12. Target and existing solar loads for Lightning Creek – East Fork Creek to Cascade Creek (ID17010213PN013_04)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
013_04	Lightning Creek	21	894	Non-Forest Group 1	29%	4.05	19	17,000	69,000	20%	4.56	20	18,000	82,000	13,000	-9%
013_04	Lightning Creek	22	3131	Non-Forest Group 1	29%	4.05	19	59,000	240,000	20%	4.56	20	63,000	290,000	50,000	-9%
013_04	Lightning Creek	23	1324	Non-Forest Group 1	29%	4.05	19	25,000	100,000	30%	3.99	20	26,000	100,000	0	1%
013_04	Lightning Creek	24	1682	Non-Forest Group 1	29%	4.05	19	32,000	130,000	40%	3.42	20	34,000	120,000	(10,000)	11%
013_04	Lightning Creek	25	3728	Non-Forest Group 1	25%	4.28	23	86,000	370,000	20%	4.56	24	89,000	410,000	40,000	-5%
							Totals		910,000					1,000,000	93,000	

Table C13. Target and existing solar loads for East Fork Creek – Idaho/Montana border to mouth (ID17010213PN014_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
014_02	Char Creek	1	274	Forest Group D	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
014_02	Char Creek	2	173	Forest Group B	98%	0.11	1	200	20	60%	2.28	1	200	500	500	-38%
014_02	Char Creek	3	990	Forest Group B	98%	0.11	2	2,000	200	70%	1.71	3	3,000	5,000	5,000	-28%
014_02	Char Creek	4	516	Forest Group B	97%	0.17	3	2,000	300	90%	0.57	4	2,000	1,000	700	-7%
014_02	Char Creek	5	567	Forest Group B	97%	0.17	3	2,000	300	80%	1.14	4	2,000	2,000	2,000	-17%
014_02	Char Creek	6	867	Forest Group B	96%	0.23	4	3,000	700	90%	0.57	5	4,000	2,000	1,000	-6%
014_02	East Fork Creek	1	170	Forest Group B	94%	0.34	5	900	300	50%	2.85	6	1,000	3,000	3,000	-44%
014_02	East Fork Creek	2	1401	Forest Group B	94%	0.34	5	7,000	2,000	80%	1.14	6	8,000	9,000	7,000	-14%
014_02	East Fork Creek	3	2780	Forest Group B	91%	0.51	7	20,000	10,000	50%	2.85	8	20,000	60,000	50,000	-41%
							Totals		14,000					83,000	70,000	

Table C14. Target and existing solar loads for East Fork Creek – Idaho/Montana border to mouth (ID17010213PN014_03)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
014_03	East Fork Creek	4	1481	Forest Group B	83%	0.97	9	13,000	13,000	30%	3.99	10	15,000	60,000	47,000	-53%
							Totals		13,000					60,000	47,000	

Table C15. Target and existing solar loads for Savage Creek – Idaho/Montana border to mouth (ID17010213PN015_02)

	Segment Details				Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
015_02	Savage Creek	1	397	Forest Group C	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
015_02	Savage Creek	2	855	Forest Group C	97%	0.17	2	2,000	300	90%	0.57	3	3,000	2,000	2,000	-7%
015_02	Savage Creek	3	640	Forest Group B	97%	0.17	3	2,000	300	90%	0.57	4	3,000	2,000	2,000	-7%

015_02	Savage Creek	4	899	Forest Group B	97%	0.17	3	3,000	500	90%	0.57	4	4,000	2,000	2,000	-7%
015_02	Savage Creek	5	899	Forest Group B	96%	0.23	4	4,000	900	90%	0.57	5	4,000	2,000	1,000	-6%
015_02	Savage Creek	6	885	Forest Group B	94%	0.34	5	4,000	1,000	80%	1.14	6	5,000	6,000	5,000	-14%
							Totals		3,100					15,000	13,000	

Table C16. Target and existing solar loads for Tribs. to Lightning Cr between Wellington & E. Fork Creek (ID17010213PN016_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
016_02	Jost Creek	1	410	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
016_02	Jost Creek	2	753	Forest Group B	98%	0.11	1	800	90	70%	1.71	1	800	1,000	900	-28%
016_02	Jost Creek	3	556	Forest Group B	98%	0.11	2	1,000	100	80%	1.14	3	2,000	2,000	2,000	-18%
016_02	Jost Creek	4	318	Forest Group B	98%	0.11	2	600	70	90%	0.57	3	1,000	600	500	-8%
016_02	Lightning Creek_Trib 01	1	234	Forest Group D	96%	0.23	1	200	50	70%	1.71	1	200	300	300	-26%
016_02	Lightning Creek_Trib 01	2	665	Forest Group D	96%	0.23	1	700	200	80%	1.14	1	700	800	600	-16%
016_02	Lightning Creek_Trib 01	3	512	Forest Group B	98%	0.11	2	1,000	100	70%	1.71	3	2,000	3,000	3,000	-28%
016_02	Lightning Creek_Trib 01	4	156	Forest Group B	98%	0.11	2	300	30	90%	0.57	3	500	300	300	-8%
016_02	Lightning Creek_Trib 01	5	121	Forest Group B	98%	0.11	2	200	20	90%	0.57	3	400	200	200	-8%
016_02	Lightning Creek_Trib 01	6	279	Forest Group B	98%	0.11	2	600	70	70%	1.71	3	800	1,000	900	-28%
016_02	Mud Creek	1	382	Forest Group C	98%	0.11	1	400	50	60%	2.28	1	400	900	900	-38%
016_02	Mud Creek	2	248	Forest Group C	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
016_02	Mud Creek	3	237	Forest Group C	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
016_02	Mud Creek	4	766	Forest Group C	97%	0.17	2	2,000	300	70%	1.71	3	2,000	3,000	3,000	-27%
016_02	Mud Creek	5	149	Forest Group C	97%	0.17	2	300	50	60%	2.28	3	400	900	900	-37%
016_02	Mud Creek	6	249	Forest Group C	96%	0.23	3	700	200	70%	1.71	4	1,000	2,000	2,000	-26%
016_02	Mud Creek	7	430	Forest Group B	97%	0.17	3	1,000	200	70%	1.71	4	2,000	3,000	3,000	-27%
016_02	Mud Creek	8	142	Forest Group B	97%	0.17	3	400	70	20%	4.56	4	600	3,000	3,000	-77%
016_02	Porcupine Creek	1	216	Forest Group C	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
016_02	Porcupine Creek	2	126	Forest Group C	98%	0.11	1	100	10	80%	1.14	1	100	100	90	-18%
016_02	Porcupine Creek	3	566	Forest Group B	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
016_02	Porcupine Creek	4	543	Forest Group B	98%	0.11	2	1,000	100	90%	0.57	3	2,000	1,000	900	-8%
016_02	Porcupine Creek	5	210	Forest Group B	98%	0.11	2	400	50	70%	1.71	3	600	1,000	1,000	-28%
016_02	Porcupine Creek	6	167	Forest Group B	98%	0.11	2	300	30	80%	1.14	3	500	600	600	-18%
016_02	Porcupine Creek	7	1657	Forest Group B	97%	0.17	3	5,000	900	80%	1.14	4	7,000	8,000	7,000	-17%
016_02	Porcupine Creek	8	166	Forest Group B	95%	0.29	4	700	200	80%	1.14	5	800	900	700	-15%
016_02	Porcupine Creek	9	350	Forest Group B	95%	0.29	4	1,000	300	80%	1.14	5	2,000	2,000	2,000	-15%
016_02	Porcupine Creek	10	608	Forest Group B	94%	0.34	5	3,000	1,000	70%	1.71	6	4,000	7,000	6,000	-24%
016_02	Porcupine Creek	11	655	Forest Group B	92%	0.46	6	4,000	2,000	80%	1.14	7	5,000	6,000	4,000	-12%

016_02	Porcupine Creek	12	332	Forest Group B	89%	0.63	7	2,000	1,000	80%	1.14	8	3,000	3,000	2,000	-9%
016_02	Porcupine Creek_Trib 01	1	462	Forest Group C	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
016_02	Porcupine Creek_Trib 01	2	337	Forest Group C	98%	0.11	1	300	30	60%	2.28	1	300	700	700	-38%
016_02	Porcupine Creek_Trib 01	3	269	Forest Group B	98%	0.11	2	500	60	60%	2.28	3	800	2,000	2,000	-38%
016_02	Porcupine Creek_Trib 01	4	520	Forest Group B	98%	0.11	2	1,000	100	80%	1.14	3	2,000	2,000	2,000	-18%
016_02	Silvertip Creek	1	752	Forest Group D	98%	0.11	1	800	90	70%	1.71	1	800	1,000	900	-28%
016_02	Silvertip Creek	2	893	Forest Group D	97%	0.17	2	2,000	300	80%	1.14	3	3,000	3,000	3,000	-17%
016_02	Silvertip Creek	3	208	Forest Group D	96%	0.23	3	600	100	90%	0.57	4	800	500	400	-6%
016_02	Silvertip Creek	4	281	Forest Group B	97%	0.17	3	800	100	90%	0.57	4	1,000	600	500	-7%
016_02	Silvertip Creek	5	504	Forest Group B	97%	0.17	3	2,000	300	80%	1.14	4	2,000	2,000	2,000	-17%
016_02	South Fork Porcupine Creek	1	554	Forest Group C	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
016_02	South Fork Porcupine Creek	2	1737	Forest Group B	98%	0.11	2	3,000	300	60%	2.28	3	5,000	10,000	10,000	-38%
016_02	South Fork Porcupine Creek	3	450	Forest Group B	97%	0.17	3	1,000	200	80%	1.14	4	2,000	2,000	2,000	-17%
016_02	Steep Creek	1	531	Forest Group B	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
016_02	Steep Creek	2	385	Forest Group B	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
016_02	Steep Creek	3	434	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
016_02	Steep Creek	4	1117	Forest Group B	98%	0.11	2	2,000	200	90%	0.57	3	3,000	2,000	2,000	-8%
016_02	Trapper Creek	1	481	Forest Group D	98%	0.11	1	500	60	50%	2.85	1	500	1,000	900	-48%
016_02	Trapper Creek	2	228	Forest Group D	98%	0.11	1	200	20	70%	1.71	1	200	300	300	-28%
016_02	Trapper Creek	3	882	Forest Group B	98%	0.11	2	2,000	200	70%	1.71	3	3,000	5,000	5,000	-28%
016_02	Trapper Creek	4	901	Forest Group B	97%	0.17	3	3,000	500	80%	1.14	4	4,000	5,000	5,000	-17%
016_02	Trapper Creek	5	89	Forest Group B	97%	0.17	3	300	50	80%	1.14	4	400	500	500	-17%
016_02	Trapper Creek	6	202	Forest Group B	97%	0.17	3	600	100	80%	1.14	4	800	900	800	-17%
							Totals		10,000					95,000	88,000	

Table C17. Target and existing solar loads for Lightning Creek – Wellington Creek to East Fork Creek (ID17010213PN016_03)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
016_03	Lightning Creek	17	574	Forest Group B	60%	2.28	15	8,600	20,000	40%	3.42	16	9,200	31,000	11,000	-20%
016_03	Lightning Creek	18	2289	Forest Group B	60%	2.28	15	34,000	78,000	40%	3.42	16	37,000	130,000	52,000	-20%
016_03	Lightning Creek	19	851	Forest Group B	58%	2.39	16	14,000	34,000	50%	2.85	17	14,000	40,000	6,000	-8%
016_03	Lightning Creek	20	3938	Non-Forest Group 1	32%	3.88	17	67,000	260,000	50%	2.85	18	71,000	200,000	(60,000)	18%
							Totals		390,000					400,000	9,000	

Table C18. Target and existing solar loads for Lightning Creek – tribs between Wellington & Rattle Creek (ID17010213PN017_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
017_02	Bear Creek	1	1236	Forest Group B	98%	0.11	1	1,000	100	70%	1.71	1	1,000	2,000	2,000	-28%
017_02	Bear Creek	2	435	Forest Group B	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%
017_02	Bear Creek	3	547	Forest Group B	98%	0.11	2	1,000	100	70%	1.71	3	2,000	3,000	3,000	-28%
017_02	Sheep Creek	1	291	Forest Group D	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
017_02	Sheep Creek	2	275	Forest Group D	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
017_02	Sheep Creek	3	715	Forest Group B	98%	0.11	2	1,000	100	90%	0.57	3	2,000	1,000	900	-8%
017_02	Sheep Creek	4	612	Forest Group B	97%	0.17	3	2,000	300	80%	1.14	4	2,000	2,000	2,000	-17%
017_02	Sheep Creek	5	364	Forest Group B	97%	0.17	3	1,000	200	90%	0.57	4	1,000	600	400	-7%
							Totals		910					9,300	9,000	

Table C19. Target and existing solar loads for Lightning Creek – Rattle Creek to Wellington Creek (ID17010213PN017_03)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
017_03	Lightning Creek	14	883	Forest Group B	70%	1.71	12	11,000	19,000	60%	2.28	13	11,000	25,000	6,000	-10%
017_03	Lightning Creek	15	2227	Forest Group B	67%	1.88	13	29,000	55,000	50%	2.85	14	31,000	88,000	33,000	-17%
017_03	Lightning Creek	16	1259	Forest Group B	63%	2.11	14	18,000	38,000	40%	3.42	15	19,000	65,000	27,000	-23%
							Totals		110,000					180,000	66,000	

Table C20. Target and existing solar loads for Rattle Creek – source to mouth (ID17010213PN018_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
018_02	Bug Creek	1	137	Forest Group B	98%	0.11	1	100	10	80%	1.14	1	100	100	90	-18%
018_02	Bug Creek	2	995	Forest Group B	98%	0.11	2	2,000	200	70%	1.71	3	3,000	5,000	5,000	-28%
018_02	Bug Creek	3	462	Forest Group B	97%	0.17	3	1,000	200	80%	1.14	4	2,000	2,000	2,000	-17%

018_02	Button Creek	1	1640	Forest Group C	98%	0.11	1	2,000	200	70%	1.71	1	2,000	3,000	3,000	-28%
018_02	Button Creek	2	535	Forest Group B	98%	0.11	2	1,000	100	80%	1.14	3	2,000	2,000	2,000	-18%
018_02	Clatter Creek	1	193	Forest Group C	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
018_02	Clatter Creek	2	347	Forest Group C	98%	0.11	1	300	30	70%	1.71	1	300	500	500	-28%
018_02	Clatter Creek	3	478	Forest Group B	98%	0.11	1	500	60	70%	1.71	1	500	900	800	-28%
018_02	Clatter Creek	4	417	Forest Group B	98%	0.11	2	800	90	80%	1.14	3	1,000	1,000	900	-18%
018_02	Clatter Creek	5	404	Forest Group B	98%	0.11	2	800	90	70%	1.71	3	1,000	2,000	2,000	-28%
018_02	Clatter Creek	6	58	Forest Group B	98%	0.11	2	100	10	60%	2.28	3	200	500	500	-38%
018_02	Rattle Creek	1	611	Forest Group B	98%	0.11	1	600	70	60%	2.28	1	600	1,000	900	-38%
018_02	Rattle Creek	2	1473	Forest Group B	98%	0.11	2	3,000	300	70%	1.71	3	4,000	7,000	7,000	-28%
018_02	Rattle Creek	3	1270	Forest Group B	95%	0.29	4	5,000	1,000	80%	1.14	5	6,000	7,000	6,000	-15%
018_02	Rattle Creek	4	314	Forest Group B	95%	0.29	4	1,000	300	80%	1.14	5	2,000	2,000	2,000	-15%
018_02	Rattle Creek	5	1240	Forest Group B	94%	0.34	5	6,000	2,000	60%	2.28	6	7,000	20,000	20,000	-34%
018_02	Rattle Creek	6	962	Forest Group B	92%	0.46	6	6,000	3,000	60%	2.28	7	7,000	20,000	20,000	-32%
018_02	Rattle Creek	7	1406	Forest Group B	89%	0.63	7	10,000	6,000	60%	2.28	8	10,000	20,000	10,000	-29%
018_02	Rattle Creek	8	489	Forest Group B	86%	0.80	8	4,000	3,000	80%	1.14	9	4,000	5,000	2,000	-6%
018_02	Rattle Creek	9	242	Forest Group B	86%	0.80	8	2,000	2,000	70%	1.71	9	2,000	3,000	1,000	-16%
018_02	Rattle Creek_Trib 01	1	261	Forest Group D	98%	0.11	1	300	30	90%	0.57	1	300	200	200	-8%
018_02	Rattle Creek_Trib 01	2	411	Forest Group B	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
018_02	Rattle Creek_Trib 01	3	844	Forest Group B	98%	0.11	1	800	90	80%	1.14	1	800	900	800	-18%
018_02	Rattle Creek_Trib 01	4	949	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	3	3,000	3,000	3,000	-18%
018_02	Rattle Creek_Trib 01	5	709	Forest Group B	97%	0.17	3	2,000	300	80%	1.14	4	3,000	3,000	3,000	-17%
							Totals		19,000					110,000	93,000	

Table C21. Target and existing solar loads for Lightning Creek – source to Rattle Creek (ID17010213PN019_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
019_02	Deer Creek	1	440	Forest Group C	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
019_02	Deer Creek	2	601	Forest Group C	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%
019_02	Deer Creek	3	1455	Forest Group B	98%	0.11	2	3,000	300	90%	0.57	3	4,000	2,000	2,000	-8%
019_02	Deer Creek	4	327	Forest Group B	97%	0.17	3	1,000	200	70%	1.71	4	1,000	2,000	2,000	-27%
019_02	Deer Creek	5	402	Forest Group B	97%	0.17	3	1,000	200	80%	1.14	4	2,000	2,000	2,000	-17%
019_02	Fall Creek	1	403	Forest Group C	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
019_02	Fall Creek	2	1408	Forest Group B	98%	0.11	2	3,000	300	70%	1.71	3	4,000	7,000	7,000	-28%
019_02	Fall Creek	3	395	Forest Group B	97%	0.17	3	1,000	200	90%	0.57	4	2,000	1,000	800	-7%
019_02	Gem Creek	1	171	Forest Group D	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
019_02	Gem Creek	2	624	Forest Group C	98%	0.11	1	600	70	80%	1.14	1	600	700	600	-18%

019_02	Gem Creek	3	715	Forest Group B	98%	0.11	2	1,000	100	80%	1.14	3	2,000	2,000	2,000	-18%
019_02	Gem Creek	4	136	Forest Group C	97%	0.17	2	300	50	80%	1.14	3	400	500	500	-17%
019_02	Gordon Creek	1	458	Forest Group D	98%	0.11	1	500	60	80%	1.14	1	500	600	500	-18%
019_02	Gordon Creek	2	1342	Forest Group B	97%	0.17	3	4,000	700	80%	1.14	4	5,000	6,000	5,000	-17%
019_02	Lightning Creek	1	225	Forest Group C	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
019_02	Lightning Creek	2	231	Forest Group C	98%	0.11	1	200	20	80%	1.14	1	200	200	200	-18%
019_02	Lightning Creek	3	918	Forest Group C	97%	0.17	2	2,000	300	90%	0.57	3	3,000	2,000	2,000	-7%
019_02	Lightning Creek	4	3037	Forest Group C	95%	0.29	4	10,000	3,000	80%	1.14	5	20,000	20,000	20,000	-15%
019_02	Lightning Creek	5	338	Forest Group C	92%	0.46	5	2,000	900	80%	1.14	6	2,000	2,000	1,000	-12%
019_02	Lightning Creek	6	600	Forest Group B	94%	0.34	5	3,000	1,000	60%	2.28	6	4,000	9,000	8,000	-34%
019_02	Lightning Creek	7	658	Forest Group B	92%	0.46	6	4,000	2,000	70%	1.71	7	5,000	9,000	7,000	-22%
019_02	Lightning Creek	8	437	Forest Group B	92%	0.46	6	3,000	1,000	60%	2.28	7	3,000	7,000	6,000	-32%
019_02	Lightning Creek	9	680	Forest Group B	89%	0.63	7	5,000	3,000	80%	1.14	8	5,000	6,000	3,000	-9%
019_02	Lightning Creek	10	1054	Forest Group B	86%	0.80	8	8,000	6,000	80%	1.14	9	9,000	10,000	4,000	-6%
019_02	Lunch Creek	1	442	Forest Group C	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
019_02	Lunch Creek	2	461	Forest Group D	98%	0.11	1	500	60	60%	2.28	1	500	1,000	900	-38%
019_02	Lunch Creek	3	403	Forest Group B	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
019_02	Lunch Creek	4	86	Forest Group B	98%	0.11	2	200	20	70%	1.71	3	300	500	500	-28%
019_02	Lunch Creek	5	177	Forest Group B	98%	0.11	2	400	50	60%	2.28	3	500	1,000	1,000	-38%
019_02	Lunch Creek	6	288	Forest Group B	98%	0.11	2	600	70	70%	1.71	3	900	2,000	2,000	-28%
019_02	Lunch Creek	7	326	Forest Group B	98%	0.11	2	700	80	50%	2.85	3	1,000	3,000	3,000	-48%
019_02	Moose Creek	1	2306	Forest Group C	98%	0.11	1	2,000	200	80%	1.14	1	2,000	2,000	2,000	-18%
019_02	Moose Creek	2	1253	Forest Group C	97%	0.17	2	3,000	500	60%	2.28	3	4,000	9,000	9,000	-37%
019_02	Moose Creek	3	154	Forest Group C	96%	0.23	3	500	100	40%	3.42	4	600	2,000	2,000	-56%
019_02	Moose Creek	4	40	Forest Group C	96%	0.23	3	100	20	70%	1.71	4	200	300	300	-26%
019_02	Moose Creek	5	107	Forest Group B	97%	0.17	3	300	50	70%	1.71	4	400	700	700	-27%
019_02	Moose Creek	6	843	Forest Group B	95%	0.29	4	3,000	900	80%	1.14	5	4,000	5,000	4,000	-15%
019_02	Moose Creek	7	171	Forest Group B	94%	0.34	5	900	300	70%	1.71	6	1,000	2,000	2,000	-24%
019_02	Quartz Creek	1	1278	Forest Group C	98%	0.11	1	1,000	100	90%	0.57	1	1,000	600	500	-8%
019_02	Quartz Creek	2	246	Forest Group C	97%	0.17	2	500	90	90%	0.57	3	700	400	300	-7%
019_02	Quartz Creek	3	418	Forest Group B	97%	0.17	3	1,000	200	90%	0.57	4	2,000	1,000	800	-7%
019_02	Quartz Creek	4	1380	Forest Group B	95%	0.29	4	6,000	2,000	80%	1.14	5	7,000	8,000	6,000	-15%
019_02	Quartz Creek	5	311	Forest Group B	94%	0.34	5	2,000	700	80%	1.14	6	2,000	2,000	1,000	-14%
019_02	Smorgasbord Creek	1	287	Forest Group C	98%	0.11	1	300	30	80%	1.14	1	300	300	300	-18%
019_02	Smorgasbord Creek	2	183	Forest Group C	98%	0.11	1	200	20	90%	0.57	1	200	100	80	-8%
019_02	Smorgasbord Creek	3	405	Forest Group C	98%	0.11	1	400	50	80%	1.14	1	400	500	500	-18%
019_02	Smorgasbord Creek	4	54	Forest Group C	97%	0.17	2	100	20	60%	2.28	3	200	500	500	-37%
019_02	Smorgasbord Creek	5	273	Forest Group C	97%	0.17	2	500	90	70%	1.71	3	800	1,000	900	-27%
019_02	Smorgasbord Creek	6	605	Forest Group C	97%	0.17	2	1,000	200	90%	0.57	3	2,000	1,000	800	-7%
							Totals		26,000					140,000	120,000	

Table C22. Target and existing solar loads for Lighting Creek – source to Rattle Creek (ID17010213PN019_03)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
019_03	Lightning Creek	11	940	Forest Group B	80%	1.14	9	8,500	9,700	70%	1.71	10	9,400	16,000	6,300	-10%
019_03	Lightning Creek	12	1433	Forest Group B	76%	1.37	10	14,000	19,000	60%	2.28	11	16,000	36,000	17,000	-16%
019_03	Lightning Creek	13	1065	Forest Group B	71%	1.65	11	12,000	20,000	60%	2.28	12	13,000	30,000	10,000	-11%
							Totals		49,000					82,000	33,000	

Table C23. Target and existing solar loads for Wellington Creek – source to mouth (ID17010213PN020_02)

Segment Details					Target					Existing					Summary	
AU	Stream Name	Number (top to bottom)	Length (m)	Vegetation Type	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Shade	Solar Radiation (kWh/m²/day)	Segment Width (m)	Segment Area (m²)	Solar Load (kWh/day)	Excess Load (kWh/day)	Lack of Shade
020_02	South Fork Wellington Creek	1	352	Forest Group C	98%	0.11	1	400	50	90%	0.57	1	400	200	200	-8%
020_02	South Fork Wellington Creek	2	808	Forest Group B	98%	0.11	2	2,000	200	90%	0.57	3	2,000	1,000	800	-8%
020_02	South Fork Wellington Creek	3	457	Forest Group B	97%	0.17	3	1,000	200	80%	1.14	4	2,000	2,000	2,000	-17%
020_02	South Fork Wellington Creek	4	429	Forest Group B	97%	0.17	3	1,000	200	60%	2.28	4	2,000	5,000	5,000	-37%
020_02	South Fork Wellington Creek	5	1056	Forest Group B	95%	0.29	4	4,000	1,000	70%	1.71	5	5,000	9,000	8,000	-25%
020_02	South Fork Wellington Creek	6	221	Forest Group B	94%	0.34	5	1,000	300	90%	0.57	6	1,000	600	300	-4%
020_02	Wellington Creek	1	630	Forest Group C	98%	0.11	1	600	70	60%	2.28	1	600	1,000	900	-38%
020_02	Wellington Creek	2	581	Forest Group C	98%	0.11	1	600	70	70%	1.71	1	600	1,000	900	-28%
020_02	Wellington Creek	3	888	Forest Group C	97%	0.17	2	2,000	300	80%	1.14	3	3,000	3,000	3,000	-17%
020_02	Wellington Creek	4	736	Forest Group B	97%	0.17	3	2,000	300	80%	1.14	4	3,000	3,000	3,000	-17%
020_02	Wellington Creek	5	473	Forest Group B	97%	0.17	3	1,000	200	90%	0.57	4	2,000	1,000	800	-7%
020_02	Wellington Creek	6	241	Forest Group B	95%	0.29	4	1,000	300	80%	1.14	5	1,000	1,000	700	-15%
020_02	Wellington Creek	7	174	Forest Group B	95%	0.29	4	700	200	90%	0.57	5	900	500	300	-5%
020_02	Wellington Creek	8	132	Forest Group B	95%	0.29	4	500	100	90%	0.57	5	700	400	300	-5%
020_02	Wellington Creek	9	100	Forest Group B	95%	0.29	4	400	100	70%	1.71	5	500	900	800	-25%
020_02	Wellington Creek	10	477	Forest Group B	95%	0.29	4	2,000	600	90%	0.57	5	2,000	1,000	400	-5%
020_02	Wellington Creek	11	79	Forest Group B	94%	0.34	5	400	100	80%	1.14	6	500	600	500	-14%
020_02	Wellington Creek	12	183	Forest Group B	94%	0.34	5	900	300	90%	0.57	6	1,000	600	300	-4%
020_02	Wellington Creek	13	150	Forest Group B	94%	0.34	5	800	300	80%	1.14	6	900	1,000	700	-14%
020_02	Wellington Creek	14	100	Forest Group B	94%	0.34	5	500	200	70%	1.71	6	600	1,000	800	-24%
020_02	Wellington Creek	15	628	Forest Group B	94%	0.34	5	3,000	1,000	90%	0.57	6	4,000	2,000	1,000	-4%
020_02	Wellington Creek	16	1579	Forest Group B	92%	0.46	6	9,000	4,000	80%	1.14	7	10,000	10,000	6,000	-12%

020_02	Wellington Creek	17	458	Forest Group B	89%	0.63	7	3,000	2,000	90%	0.57	8	4,000	2,000	0	1%
020_02	Wellington Creek_Trib 01	1	361	Forest Group B	98%	0.11	1	400	50	70%	1.71	1	400	700	700	-28%
020_02	Wellington Creek_Trib 01	2	798	Forest Group B	98%	0.11	2	2,000	200	80%	1.14	3	2,000	2,000	2,000	-18%
020_02	Wellington Creek_Trib 01	3	625	Forest Group B	97%	0.17	3	2,000	300	90%	0.57	4	3,000	2,000	2,000	-7%
							Totals		13,000					53,000	41,000	

Appendix D. Managing Stormwater

Municipal Separate Storm Sewer Systems

Polluted stormwater runoff is commonly transported through municipal separate storm sewer systems (MS4s), from which it is often discharged untreated into local water bodies. An MS4, according to 40 CFR 122.26(b)(8), is a conveyance or system of conveyances that meets the following criteria:

- Owned by a state, city, town, village, or other public entity that discharges to waters of the US
- Designed or used to collect or convey stormwater (including storm drains, pipes, ditches, etc.)
- Not a combined sewer
- Not part of a publicly owned treatment works (sewage treatment plant)

To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a NPDES permit from the US Environmental Protection Agency (EPA), implement a comprehensive municipal stormwater management program (SWMP), and use best management practices (BMPs) to control pollutants in stormwater discharges to the maximum extent practicable.

Industrial Stormwater Requirements

Stormwater runoff picks up industrial pollutants and typically discharges them into nearby water bodies directly or indirectly via storm sewer systems. When facility practices allow exposure of industrial materials to stormwater, runoff from industrial areas can contain toxic pollutants (e.g., heavy metals and organic chemicals) and other pollutants (e.g., trash, debris, oil and grease). This increased flow and pollutant load can impair water bodies, degrade biological habitats, pollute drinking water sources, and cause flooding and hydrologic changes (e.g., channel erosion) to the receiving water body.

Multi-Sector General Permit and Stormwater Pollution Prevention Plans

In Idaho, if an industrial facility discharges industrial stormwater into waters of the US, the facility must be permitted under EPA's most recent Multi-Sector General Permit (MSGP). To obtain an MSGP, the facility must prepare a stormwater pollution prevention plan (SWPPP) before submitting a notice of intent for permit coverage. The SWPPP must document the site description, design, and installation of control measures; describe monitoring procedures; and summarize potential pollutant sources. A copy of the SWPPP must be kept on site in a format that is accessible to workers and inspectors and be updated to reflect changes in site conditions, personnel, and stormwater infrastructure.

Industrial Facilities Discharging to Impaired Water Bodies

Any facility that discharges to an impaired water body must monitor all pollutants for which the water body is impaired and for which a standard analytical method exists (see 40 CFR Part 136).

Also, because different industrial activities have sector-specific types of material that may be exposed to stormwater, EPA grouped the different regulated industries into 29 sectors, based on their typical activities. Part 8 of EPA's MSGP details the stormwater management practices and monitoring that are required for the different industrial sectors. DEQ anticipates including specific requirements for impaired waters as a condition of the 401 certification. The MSGP will detail the specific monitoring requirements.

TMDL Industrial Stormwater Requirements

When a stream is on Idaho's §303(d) list and has a TMDL developed, DEQ may incorporate a wasteload allocation for industrial stormwater activities under the MSGP. However, most load analyses developed in the past have not identified sector-specific numeric wasteload allocations for industrial stormwater activities. Industrial stormwater activities are considered in compliance with provisions of the TMDL if operators obtain an MSGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The next MSGP will have specific monitoring requirements that must be followed.

Construction Stormwater

The Clean Water Act requires operators of construction sites to obtain permit coverage to discharge stormwater to a water body or municipal storm sewer. In Idaho, EPA has issued a general permit for stormwater discharges from construction sites.

Construction General Permit (CGP) and Stormwater Pollution Prevention Plans

If a construction project disturbs more than 1 acre of land (or is part of a larger common development that will disturb more than 1 acre), the operator is required to apply for a CGP from EPA after developing a site-specific SWPPP. The SWPPP must provide for the erosion, sediment, and pollution controls they intend to use; inspection of the controls periodically; and maintenance of BMPs throughout the life of the project. Operators are required to keep a current copy of their SWPPP on site or at an easily accessible location.

TMDL Construction Stormwater Requirements

When a stream is on Idaho's §303(d) list and has a TMDL developed, DEQ may incorporate a gross wasteload allocation for anticipated construction stormwater activities. Most loads developed in the past did not have a numeric wasteload allocation for construction stormwater activities. Construction stormwater activities are considered in compliance with provisions of the TMDL if operators obtain a CGP under the NPDES program and implement the appropriate BMPs. Typically, operators must also follow specific requirements to be consistent with any local pollutant allocations. The CGP has monitoring requirements that must be followed.

Postconstruction Stormwater Management

Many communities throughout Idaho are currently developing rules for postconstruction stormwater management. Sediment is usually the main pollutant of concern in construction site stormwater. DEQ's *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties* (DEQ 2005b) should be used to select the proper suite of BMPs for the specific site, soils, climate, and project phasing in order to sufficiently meet the standards and requirements of the CGP to protect water quality. Where local ordinances have more stringent and site-specific standards, those are applicable.

Appendix E. Pollutant Trading

Pollutant trading (also known as water quality trading) is a contractual agreement to exchange pollution reductions between two parties. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost-effective, local solutions to problems caused by pollutant discharges to surface waters. Pollutant trading is one of the tools available to meet reductions called for in a TMDL where point and nonpoint sources both exist in a watershed.

The appeal of trading emerges when pollutant sources face substantially different pollutant reduction costs. Typically, a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction.

Pollutant trading is voluntary. Parties trade only if both are better off because of the trade, and trading allows parties to decide how to best reduce pollutant loadings within the limits of certain requirements.

Pollutant trading is recognized in Idaho's water quality standards at IDAPA 58.01.02.055.06. DEQ allows for pollutant trading as a means to meet TMDLs, thus restoring water quality limited water bodies to compliance with water quality standards. DEQ's *Water Quality Trading Guidance* sets forth the procedures to be followed for pollutant trading (DEQ 2016b).

Trading Components

The major components of pollutant trading are trading parties (buyers and sellers) and credits (the commodity being bought and sold). Ratios are used to ensure environmental equivalency of trades on water bodies covered by a TMDL. All trading activity must be recorded in the trading database by DEQ or its designated party.

Both point and nonpoint sources may create marketable credits, which are a reduction of a pollutant beyond a level set by a TMDL:

- Point sources create credits by reducing pollutant discharges below NPDES effluent limits set initially by the wasteload allocation.
- Nonpoint sources create credits by implementing approved BMPs that reduce the amount of pollutant runoff. Nonpoint sources must follow specific design, maintenance, and monitoring requirements for that BMP; apply discounts to credits generated, if required; and provide a water quality contribution to ensure a net environmental benefit. The water quality contribution also ensures the reduction (the marketable credit) is surplus to the reductions the TMDL assumes the nonpoint source is achieving to meet the water quality goals of the TMDL.

Watershed-Specific Environmental Protection

Trades must be implemented so that the overall water quality of the water bodies covered by the TMDL is protected. To do this, hydrologically based ratios are developed to ensure trades between sources distributed throughout TMDL water bodies result in environmentally equivalent or better outcomes at the point of environmental concern. Moreover, localized adverse impacts to water quality are not allowed.

Trading Framework

For pollutant trading to be authorized, it must be specifically mentioned within a TMDL document. After adoption of an EPA-approved TMDL, DEQ, in concert with the WAG, must develop a pollutant trading framework document. The framework would mesh with the implementation plan for the watershed that is the subject of the TMDL. The elements of a trading document are described in DEQ's pollutant trading guidance (DEQ 2016b).

Appendix F. Public Participation and Public Comments

This TMDL was developed with participation from the Lower Clark Fork Watershed Advisory Group.

Comment from the Panhandle Chapter of Trout Unlimited:

The Panhandle Chapter of Trout Unlimited supports the national TU mission to conserve, protect, and restore North Idaho's cold-water fisheries and watersheds. We appreciate the opportunity to be involved in this and other efforts to protect and enhance water quality in the Lower Clark Fork and other North Idaho sub basins. For future 303d temperature listings, we encourage DEQ to consider a cold-water refuge approach that could complement the shade targets prescribed in the Lower Clark Fork Temperature TMDL using the PNV approach. A USEPA primer for identifying cold-water refuges is available at *https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NHEERL&dirEntryId=243611*.

Thanks again for the opportunity to comment and participate in the process.

Idaho Department of Environmental Quality Response to Comment:

The Idaho Department of Environmental Quality appreciates the input, guidance, and suggestions for this Lower Clark Fork TMDL and future TMDL development. Thank you for sharing this approach and the modeled stream flow metrics document.
https://www.fs.fed.us/rm/boise/AWAE/projects/modeled_stream_flow_metrics.shtml